OXFORD

Wetland Archaeology and Beyond

Theory and Practice

Francesco Menotti

WETLAND ARCHAEOLOGY AND BEYOND

This page intentionally left blank

Wetland Archaeology and Beyond

Theory and Practice

FRANCESCO MENOTTI

OXFORD
UNIVERSITY PRESS

OXFORD
UNIVERSITY PRESS

Great Clarendon Street, Oxford, OX2 6DP,
United Kingdom

Oxford University Press is a department of the University of Oxford.
It furthers the University's objective of excellence in research, scholarship,
and education by publishing worldwide. Oxford is a registered trade mark of
Oxford University Press in the UK and in certain other countries

First Edition published in 2012

Impression: 1

British Library Cataloguing in Publication Data
Data available

Library of Congress Cataloguing in Publication Data
Data available

ISBN 978–0–19–957101–7

Printed in Great Britain
on acid-free paper by
MPG Books Group, Bodmin and King's Lynn

To the memory of
Andrew Sherratt
(1946–2006)
Teacher, colleague, and friend

This page intentionally left blank

Preface and Acknowledgements

Despite the ubiquitous aspect of wetland archaeology, it is still quite common to have people gaze at me with wonder when I say that I am a wetland archaeologist. Out of politeness, some people pretend to be interested and smile, others, after a feeble: 'interesting!', find the courage to ask more directly: 'but . . . what is it?' Before I am able to come up with a plausible answer, a series of impatient questions follows: 'what do you mean by wetland?' . . . 'do you work in bogs or swamps?' . . . 'why would people live in such places, anyway?' It becomes even more frustrating when colleagues ask me what exactly it is that I am dealing with, and, after my patient explanation, they reply: 'I see, well, then I guess I am a wetland archaeologist too!' Some fifteen years within the discipline and a series of misunderstandings as to what wetland archaeology might be have convinced me to write this book, in an attempt to clarify long-overdue issues that, while stimulating the interest of the general public, have also triggered incandescent debates amongst scholars. The aim of this volume is to consider the various aspects of wetland archaeology in order to pinpoint those factors, which have not only hindered the full potential of the discipline, but, in some cases, also tended to isolate it from mainstream archaeology.

The various themes discussed in the book attempt to cover the whole world, but the reader will soon realize that some areas are dealt with in more detail and mentioned more often than others. This is, of course, partly due to my own biases and knowledge, but also due to the fact that in some areas more abundant and detailed research has been carried out than in others (see for instance Chapters 2 and 4, where the amount of information on Europe is noticeably higher than for other parts of the world). Moreover, the rather long list of wet/wetland archaeological sites mentioned throughout the volume is certainly not meant to be exhaustive. Hence, the fact that some sites have been left out is due either to my own ignorance or to their irrelevance in the topic discussed at that specific moment.

The various chapters are ordered in a way that takes the reader through a sort of chronological journey, from the dawn of wetland archaeology to the large amount of archaeological evidence available now; how this evidence is found, retrieved, and studied; why it is important to place it in a wider sociocultural and geographical context; and finally, how to protect it for future generations. Chapter 1, for instance, guides the reader through the biographical development of wetland archaeology as well as considering how the discipline is perceived in different countries. The large number of wetland archaeological sites mentioned in Chapter 2 shows the significance of people–wetlands

interaction all over the world. Chapter 3 interfaces this long, worldwide list of wetland occupations with the overwhelming amount of archaeological evidence that they produced (which is discussed in Chapter 4). The intention of Chapter 3 is to help the reader understand the various processes of interaction and adaptation people had with the environment, and to realize that such relationships were (and still are) far from casual, but the result of carefully planned sociocultural strategies. Although very well preserved, this richness of archaeological evidence is not easy to locate, and in the majority of cases foremost discoveries were/are the result of serendipitous actions. Difficulties continue even after the archaeological remains are found, for different waterlogged contexts require particular excavation techniques. Chapter 5 takes the reader through the entire process of locating, retrieving, protecting, and conserving that array of beautifully preserved, yet exceedingly delicate ancient organic materials. Although addressing matters closely related to wetland archaeology, Chapters 6 and 7 go beyond the typical characteristics and functions of the discipline. Chapter 6 discusses the multidisciplinary orientation of wetland archaeology, listing a number of various disciplines (within and beyond archaeological research) that, in a synergetic effort, demonstrate how the potential of well-preserved organic remains can be fully exploited. At the same time, Chapter 7 shows that despite immaculate preservation, the function and performance of some artefacts are sometimes difficult to recognize, hence the importance of experimental archaeology in proving or disproving educated guesses. Chapter 8, while still appreciating the value of high-resolution archaeological evidence (often used by wetland archaeology as an endorsement for the discipline), highlights the importance of placing such evidence in a wider social and geographical context if we want to understand it entirely. Most importantly, the chapter argues that no matter how detailed archaeological evidence is, it does not speak for itself; a solid body of theory is still required to appreciate completely whoever created that material culture in the first place. Finally, Chapter 9 aims at raising awareness of the inexorable disappearance of the wetlands, and, with them, our invaluable cultural heritage. Measures need be taken, and most urgently! Notwithstanding its good intentions, this is, alas, a battle that wetland archaeology alone cannot win, but needs the help of the entire society.

A series of maps (placed at the end of the volume) will help the reader locate the major archaeological sites and locations mentioned throughout the book. Although the single map locations are pointed out only in Chapter 2, the reader can locate any site in every chapter through a systematically structured layout of the maps (from the main World Map to the various sub-maps), or through the list of maps placed before the maps themselves. Finally, a useful glossary, with which the reader can familiarize her- or himself with unfamiliar terms, is also placed after the Epilogue.

Writing a book is not only about spending hours and hours each day on the computer, in libraries, and on fieldwork, it is also about learning to appreciate the invaluable help of colleagues and friends. There are quite a few people to whom I am truly in debt, and without whom this book could have never been written. First of all, I would like to express my sincere gratitude to Ben Jennings for creating all the maps, developing and elaborating a number of figures, and helping me with a million other things. A special thanks also goes to José Granado for painstakingly storing and checking all the references, and to Olenka Dmytryk for preparing the numerous line drawings. I also appreciate the generous availability of Dale Croes, who helped me with the section on North America and other vital information. For his willingness to give me a hand whenever I needed and for the stimulating discussions on a variety of topics, I would also like to thank Urs Leuzinger.

A number of scholars have provided me with crucial information throughout the research and writing of the book. Amongst them I would particularly like to mention (in alphabetical order): Claude Albore Livadie, Kurt Altdorfer, Beat Arnold, Stijn Arnoldussen, Martin Bachmann, Geoff Bailey, Eszter Bánffy, Andreas Bauerochse, Jens-Henrik Bech, Martin Bell, Paolo Bellintani, Kathryn Bernick, Jaap Beuker, André Billamboz, Mihael Budja, Bryony Coles, John Coles, Richard Daugherty, Glen Doran, Otto Ehrmann, Maria Antonietta Fugazzola-Delpino, Serlegi Gabor, Markus Graf, Albert Hafner, Tom Higham, Stefan Hochuli, Per Hoffmann, Renata Huber, Geoff Irwin, Dilys Johns, Marc-Antoine Kaeser, Ruth Kirk, Hiroyuki Kitagawa, Joachim Köninger, Matthieu Le Bailly, Oriol López, Michel Magny, Ursula Maier, Nicoletta Martinelli, Franco Marzatico, Akira Matsui, Felix Müller, Aidan O'Sullivan, Pierre Pétrequin, Natascia Pizzano, Barbara Purdy, Denis Ramseyer, Peter Riethmann, Helmut Schlichtherle, Gunter Schöbel, Tatiana Theodoropoulou, Gilles Touchais, Robert Van de Noort, Clive Waddington, Lydia Zapata, Yunfei Zheng, and Mickle Zhilin.

I am also grateful to all the members of the Institute of Prehistory and Archaeological Science, Basel University for their support and understanding of my lack of availability throughout the writing of the book; in particular I would like to thank (in alphabetical order): Thomas Doppler, Renate Ebersbach, Brigitte Heiz-Wyss, Karin Huck, Kristin Ismail-Meyer, Heide Hüster-Plogmann, Stefanie Jacomet, Britta Pollmann, Philippe Rentzel, Jörg Schibler, and Philipp Wiemann for their interesting insights on a number of topics. A special thank you goes to Angela Schlumbaum for her moral support, interesting discussions of ancient DNA analyses, and delicious food! For their encouragement and stimulating conversations I would like to say thank you to Rosemarie and Peter Hidber. I also thank the Oxford University Press anonymous readers for their invaluable comments and criticism, Hilary O'Shea for

her patience in corresponding with me at the early stage of my book proposal, and Taryn Campbell for her exceptional kindness in helping me with a myriad of issues. Finally, a special word of gratitude goes to Anjushka Hurina for her heartfelt support throughout the lengthy gestation of this book.

F.M.

Basel
December 2010

Contents

List of Figures

List of Tables

Dating Abbreviations

Radiocarbon dates

BP	uncalibrated Before Present
cal BP	calibrated Before Present
cal BC/AD	calibrated Before Christ/Anno Domini
bc	uncalibrated Before Christ

Dendrochronology and/or historical dates

BC/AD

1

Wetland Archaeology Inside Out

INTRODUCTION

We often hear the term 'wetland archaeology', and we probably know that it is a subdiscipline of mainstream archaeology, which deals with waterlogged ancient remains. However, do we really know its origins and how it developed to become one of the most active, yet unappreciated fields of research within the parental discipline of archaeology? Are we really aware that in most countries wetland archaeology is not even regarded as a subdiscipline of archaeology, but integrated within it without any distinction? And finally, do we really know that wetland archaeology is one of the most active and multidisciplinary-oriented interfaces between the humanities and natural sciences?

This chapter takes the reader through the discipline's biographical development, from Ferdinand Keller to New Archaeology, explaining the reason why, despite its great potential to make a significant contribution to the mainstream of archaeological thought, wetland archaeology has been experiencing an odd process of isolation in some countries (Van de Noort and O'Sullivan, 2006). The chapter also clarifies some aspects of wetland archaeological research, that despite being taken for granted, are often misunderstood. It explains, for instance, the differences between the various ecosystems, and how these differences influenced people's choice to select them for exploitation (Dinnin and Van de Noort, 1999). It also elucidates the difference between wet and wetland sites, and how this distinction may be crucial for palaeoenvironmental reconstructions and subsequent site analyses (Nicholas, 2001). Without diminishing the importance of well-preserved organic material culture and larger architectural structures, it is pointed out that one of the main strengths of waterlogged environments is their capacity to preserve a large quantity of artefacts that allow wetland archaeology to contribute to a myriad of multidisciplinary projects extending far beyond the boundaries of archaeology (Corfield, 2007).

The internationality of wetland archaeological research is unrecognized in a number of countries where wetland archaeology is not acknowledged as a

proper subdiscipline of mainstream archaeology. As discussed in the penultimate subsection below, under 'Wetland Archaeology as Academic Discipline', this is the result of a series of intertwined factors linked to the different research traditions of individual countries.

The final part of the chapter discusses a crucial aspect of wetland archaeology, which extends far beyond the purpose of the discipline but influences it directly: wetland preservation (Coles, 1995; Coles and Olivier, 2001). This is a goal that wetland archaeology alone can certainly not achieve successfully, without the help of the whole society. Hence the importance of ensuring that the general public is properly informed and engaging local, national, and international authorities in policy-making strategies to protect natural wetland environments and, with them, our invaluable cultural heritage.

Most of the topics mentioned within the chapter are not discussed exhaustively, but are introduced only broadly. Appropriate links to other chapters will enable the reader to gain more in-depth information on specific themes.

WETLAND ARCHAEOLOGY: HOW DID IT ALL BEGIN?

Before Ober-Meilen

Although the beginning of wetland archaeology is conventionally seen as the discovery of the Ober-Meilen (Lake Zurich, Switzerland) prehistoric lacustrine settlement in 1854, waterlogged archaeological remains had been found and recorded well before that date. In fact, one of the very first finds was a bog body discovered by a group of peat diggers from Bönsdörp in Germany in the mid-fifteenth century (Coles and Coles, 1989). Peat extraction has, since then, facilitated the discovery of a large number of such human remains all over northern Europe and the British Isles, but the majority of them were, alas, destroyed or reburied immediately. Proper recording and study of such unique archaeological evidence started only after the Second World War, and in some cases even later (see also Ch. 4, under 'Bog Bodies'). Peatbogs and other waterlogged contexts yielded not only bog bodies, but also a myriad of well-preserved organic artefacts, such as wooden wheels, trackways, and dugouts (see for instance the discovery and recording of the 12-km long Valtherbrug trackway in the Netherlands, and the number of canoes found along the River Clyde in Scotland, in the early nineteenth century). Even crannogs in Scotland and Ireland were known well before the Swiss lake-dwellings. One of the best examples is the Lagore crannog (Co. Meath); although not properly excavated until 1950 (H. Hencken, 1950), part of its rich archaeological assemblage was already known in the late 1830s (Petrie, 1853; Wilde, 1840) (see also Ch. 2, under 'From AD 1 Onwards'). Another

sensational pre-Keller discovery was made at Inver (Co. Donegal) in 1833, when the remains of an exceedingly well-preserved rectangular wooden structure (with two levels or compartments) were found under 3 metres of peat (Wood-Martin, 1886*a*, *b*). The structure was initially thought to be a dwelling (maybe a crannog), but more recently it has been suggested that it could have been a mortuary house (Coles and Coles, 1989: 17). A number of prehistoric objects and wooden structures were also located on various lakes of the Circum-Alpine region before 1854 (e.g. Nidau on Lake Biel in 1472, at Arbon on Lake Constance in the mid-sixteenth century, on Lake Luissel in 1791, and on Lake Sempach in 1806) (Speck, 1981, 1990*a*), but unlike to the Ober-Meilen settlement, they were never officially reported.

From Ferdinand Keller Onwards

It was thanks to the receding waters of Lake Zurich (Switzerland) during the bitterly cold 1853–4 winter that, walking on the shore, Johannes Aeppli discovered the prehistoric village of Ober-Meilen. Certainly unaware of the enormous repercussions that the discovery would have on archaeology as an academic discipline in the years to come, Aeppli reported it to the Antiquarian Association in Zurich. The site was promptly studied by Ferdinand Keller, who within the same year published a detailed report: *Die keltische Pfahlbauten in den Schweizerseen* (Keller, 1854). The success of this publication and those that followed triggered an incredible interest in prehistoric lake-dwelling artefacts, resulting in unprecedented searches for new sites, first confined to Switzerland, then within the Circum-Alpine region, and eventually expanding to cover the whole of Europe. This so-called *Pfahbaufieber* (lake-dwelling rush) was initially far from scientific; the main purpose was in fact purely financial. Fishermen abandoned their traditional gear for more 'sophisticated' tools able to fish the more profitable material from the bottom of the lake (Altorfer, 2004*b*; Desor, 1865) (see Fig. 1.1).

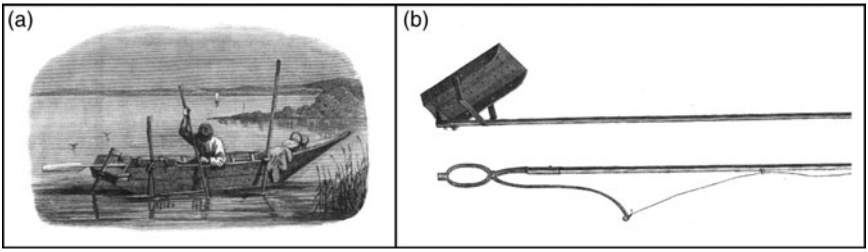


Fig. 1.1. Edouard Desor's drawings, showing a fisherman collecting lacustrine artefacts (a), with his 'special' fishing gear (b). (After Desor, 1865)

At the same time, impromptu antiquarians made their fortunes by selling illegally gathered artefacts to collectors and museums worldwide (Altorfer, 2004*b*). The tourism industry also profited from the popularity of lake-dwelling sites. In fact, as fast as the artefacts were leaving Switzerland, tourists were flocking in to visit the famous sites. Because of its well-preserved artefacts, and the meticulous work of Jakob Messikommer, Wetzikon-Robenhausen (Lake Pfäffikon) became a very popular destination. Not only were tourists visiting the site, but, as listed by Messikommer in his guestbook, also famous scholars such as Charles Lyell (Fig. 1.2), Heinrich Schliemann, and Oscar Montelius (Altorfer, 2004*a*: 93–4).

Meanwhile, the lake-dwelling 'fever' spread over the entire Circum-Alpine region, and to various parts of northern Europe. By 1866, six of Keller's *Berichte* (reports) had already been translated into English and published by J. E. Lee (Keller, 1866). A decade passed, more *Berichte* came out, and an updated second edition of the book was published in 1878 (Keller, 1878). In countries rich in lakes, such as Ireland and Scotland, the popularity of the lake-dwelling settlements was fairly high. Amongst the various scholars that in one way or another worked on prehistoric and historic lacustrine settlements (e.g. crannogs), two in particular have produced invaluable contributions to the

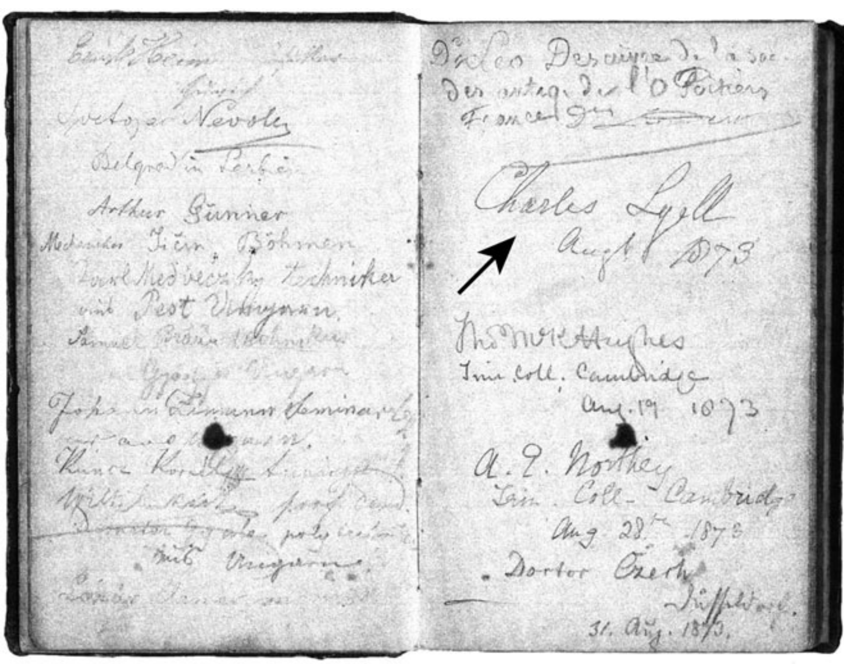


Fig. 1.2. Jakob Messikommer's Robenhausen guestbook with Charles Lyell's signature and date of the visit (see arrow). (*Photograph*: courtesy of Kurt Altorfer)

lake-dwelling research. The main figure in Scotland was Robert Munro, with two major books, *Ancient Scottish Lake-Dwellings or Crannogs* (1882) and *The Lake-Dwellings of Europe* (1890). He even produced a third volume on the *terramare*, after the incandescent debate on their origins and functions, at the end of the nineteenth century (Munro, 1912). In Ireland, it was William G. Wood-Martin, with his *The Lake-Dwellings of Ireland* (1886*b*) that established solid foundations for future lake-dwelling research. All the above-mentioned publications inspired a number of scholars; one in particular was Arthur Bulleid, whose determination and perseverance finally brought him to discover the famous lake village of Glastonbury (Bulleid and Gray, 1911, 1917) (see also Ch. 4, under 'Settlements and Simple Agglomerations of Houses').

By the end of the nineteenth century, a large number of wetland sites (at this point still regarded as lake settlements, although some of them were obviously not) had been located in various parts of northern Europe, from the British Isles to Russia. The influence of Keller's writing was, however, not limited to the European continent, but also crossed the Atlantic, spreading throughout North America, with a special emphasis on Florida. It was in fact there, thanks to a landowner and a colonel of the British Army, that Frank Cushing started to work on the famous site of Key Marco, and discovered a large number of wooden sculptures and masks, which were to become known all over the world (Cushing, 1897).

In the meantime back in Switzerland, the lake-dwelling phenomenon had started to lose its pecuniary aspect, moving further towards a political orientation. After the 1847 civil war, the *Sonderbundskrieg* (separate alliance), Switzerland was searching for a national unity and Keller's 'platform' was the perfect example of the *Helvetia Sonderfall* (the Swiss exception), symbolizing the strong and independent Swiss identity (Kaeser, 2002, 2004*b*, 2010). The influence of the artificially constructed *Pfahlbaukultur* (lake-dwelling culture) spread through the various aspects of Swiss life, from art (Fig. 1.3), literature (Fig. 1.4), and architecture (e.g. Le Corbusier's buildings), to both primary and secondary education (Achermann, 1920; Helbling-Gloor, 2004; Kaeser, 2004*a*, 2005; A. M. Vogt, 2004). The Swiss lake-dwelling pride was of course not limited to elite society but was also embedded in everyday life, and even used to promote commercial products (Fig. 1.5) (Kaeser, 2008*b*).

It was indeed this artificial cultural construction of the lake-dwelling phenomenon that perpetuated Keller's concept of pile-dwellings on wooden platforms surrounded by water (Fig. 1.6), for more than seventy years (Keller, 1854).

The first signs of movement were noticed at the beginning of the twentieth century, when the scientific aspect of archaeology started to emerge (see also Ch. 6). However, it was not until the 1920s that Schmidt and Reinerth (continuing the pioneering work of Frank (1876, 1892) on Lake Feder, Germany), advanced the hypothesis that the lake-dwellings might have not stood in the water all year around. The confirmation came from the cofferdam

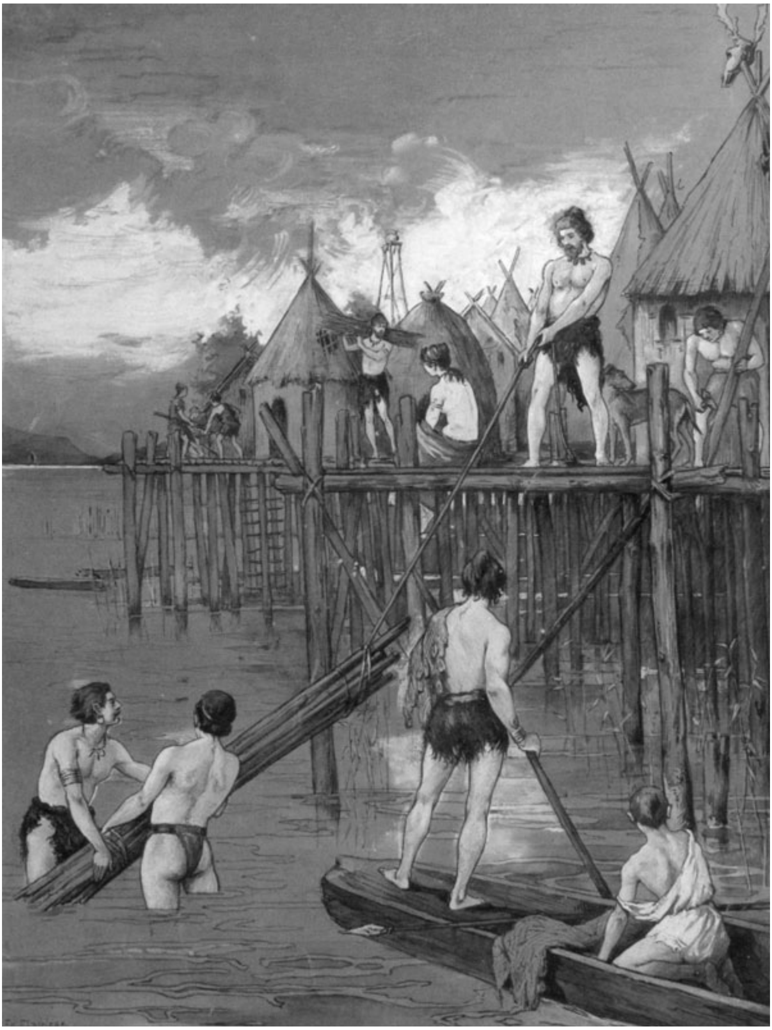


Fig. 1.3. Edouard Elzingre's painting: *Scène Lacustre* (*c.*1905) (*Photograph*: courtesy of Marc-Antoine Kaeser, Laténium Museum, Neuchâtel, Switzerland)

excavation at Sipplingen (Lake Constance, Germany), in the late 1920s (see also Ch. 5 and Fig. 5.11), with which Reinerth was able to show that the lake-dwellings were indeed constructed on stilts, but that they were only inundated periodically (Fig. 1.7) (Reinerth, 1932).

Reinerth's research triggered what is known as the *Pfahlbauproblem* (the lake-dwelling dispute), which would not be resolved until fairly recently (1970–80s). A further and decisive attack on Keller's theory was launched by Paret (1942, 1958). Of course, his proposition was promptly rejected by Swiss

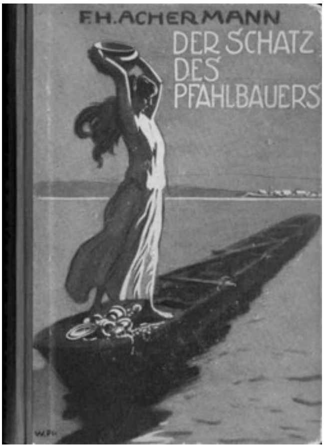


Fig. 1.4. Achermann's book: *Der Schatz des Pfahlbauers* (1920). (After Achermann, 1920)

Fig. 1.5. Commercial advertising using the popularity of the lake-dwellings (*Photograph*: courtesy of Marc-Antoine Kaeser, Laténium Museum, Neuchâtel, Switzerland)

scholars (e.g. Keller-Tarnuzzer, 1944, 1945), until the meticulous excavation of Emil Vogt at Egolzwil 3 (in the Wauwil peat moor, near Lucerne) provided irrefutable evidence that the lake-dwellings were in fact 'lakeside dwellings' (E. Vogt, 1951). Paret's theory (see Fig. 1.7) was eventually accepted by the majority of Swiss scholars, and the hundredth jubilee of the lake-dwelling (stilts and platform) discovery (1954) was celebrated, ironically, by denying

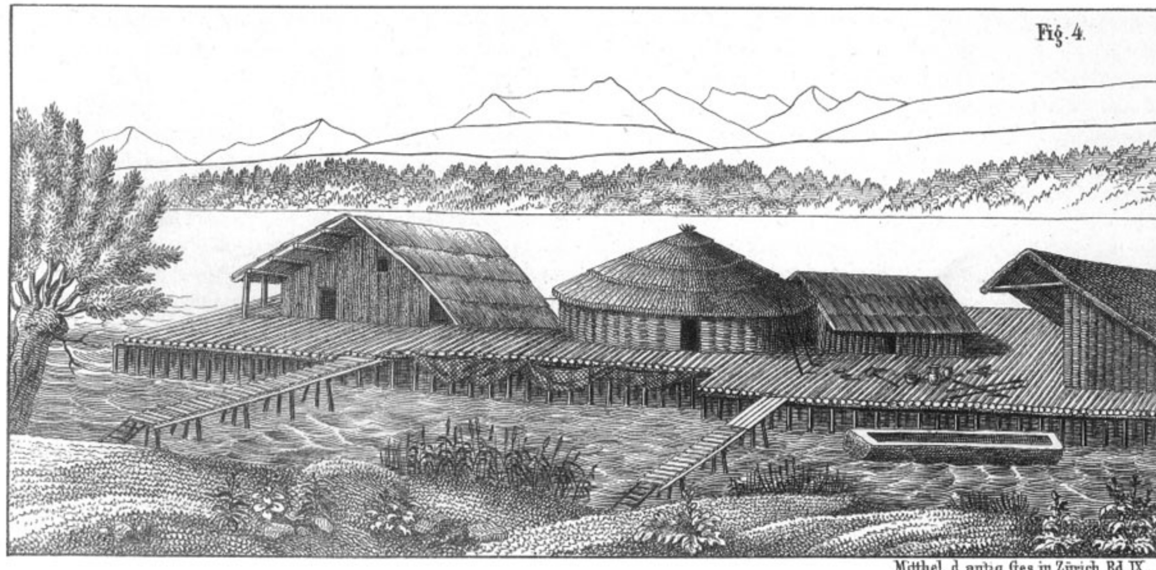


Fig. 1.6. Keller's first reconstruction of the Ober-Meilen pile-dwellings. (After Keller, 1854: plate I, fig. 4)

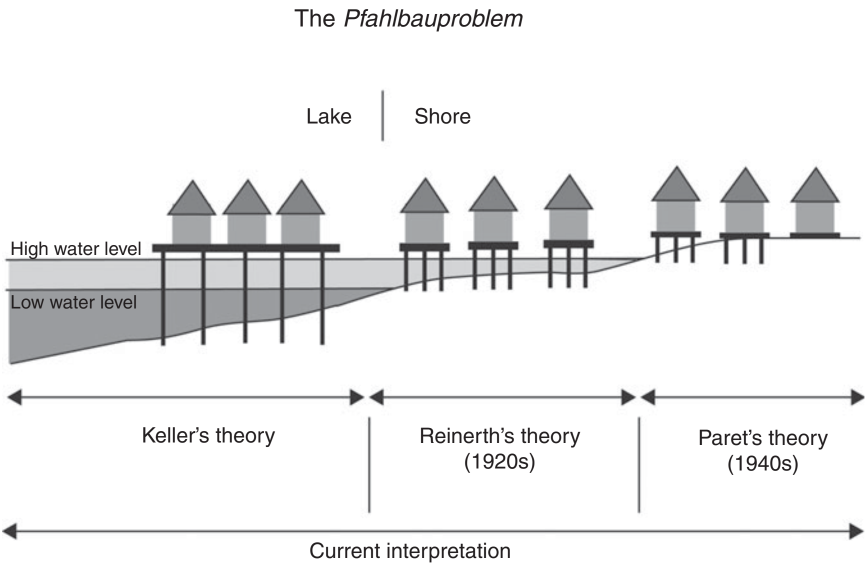


Fig. 1.7. Schematic representation of the *Pfahlbauproblem* development. (Modified from Menotti 2001)

their existence (E. Vogt, 1955). The *Pfahlbauproblem* did not make the headlines for more than a decade, until the economic boom brought about new lake-dwelling discoveries. It was in fact thanks to these new discoveries, and most importantly to the advent of 'New Archaeology' (Binford, 1981, 1983) (with the possibility of using new scientific methods of analysis, e.g. ^{14}C, dendrochronology, etc. see also Ch. 6) that it was soon realized that Keller, Reinerth, and Paret were all correct. This led to the acceptance that, rather than a single kind of lake-dwelling, various kinds existed (e.g. Fiavé, northern Italy) (Perini, 1984, 1987). Houses and settlements were constructed in the water, on stilts on the shore, and also directly on the ground (never influenced by the fluctuating water); and they were all labelled as lake-dwellings.

New Research Orientations

Once the lake-dwelling dispute was resolved, the orientation of research moved towards chronology and environmental issues linked to occupational patterns and economy. New methodologies of analysis soon revealed the enormous potential of the well-preserved organic material found in waterlogged contexts. All of a sudden, chronologies as precise as ±1 year could be established, economies, diets, and the environment reconstructed, and even the aesthetic appearance of our ancestors be seen (e.g. bog bodies). It was as

though archaeological evidence was talking to us, without the need for any theoretical conception. Major archaeological discoveries from all over the world, from the Sweet Track, the Glastonbury lake village, Star Carr, Flag Fen, and Biskupin in Europe, to Ozette and Windover in North America have certainly fascinated and attracted the attention of numerous archaeologists. Ironically enough though, instead of these sites being integrated into mainstream archaeology more easily (because of their remarkably detailed data), they produced a schism between the two disciplines that in some countries even led to a complete decontextualization of wet/wetland archaeological sites from their surroundings (see below). As discussed in the following sections, this separation, or more precisely, failed integration, of wetland archaeology from mainstream archaeological thought is a multifaceted combination of factors, involving inadequate (or totally lacking) theoretical approaches and different research traditions, which struggled to adapt to the unexpected richness of the data. However, it has become more and more clear that one of the major causes of this isolation was the failure to understand the various wetland ecosystems and the important role they played in a wider cultural and geographical theatre. It is only by being aware of how single ecosystems are appreciated from 'inside' that they can eventually be linked to the 'outside'. Since the majority of people interacting with the wetlands did not necessarily live within them, a decontextualized synchronic study of single archaeological sites, or ecosystems, will inexorably lead to biased and counterproductive conclusions.

THE WETLANDS: A MYRIAD OF ECOSYSTEMS

Although eighteenth- and nineteenth-century writers might have described waterlogged environments as 'wet lands', the use and etymology of the one-word term 'wetlands' is a fairly recent development. In literature it was first noticed in the 1950s–1960s (*Science New Letter* (281/2, 29 October 1955); *New Scientist* (263/3, 17 June 1965), and *Nature* (239/2, 19 April 1969)), describing wet habitats for waterfowl, but it was not until the international convention on wetlands in Ramsar, Iran 1971 (<www.ramsar.org>) that the term became internationally recognized.

People in the past did not see the landscape as environmental ecosystems. They developed instead specific native ecologies, using particular terminology to name determinate topographic features (R. Bradley, 2000; M. Harris, 2000; Ingold, 1995). In fact, some terms for the different ecosystems that we use today derive from ancient words (e.g. Anglo-Saxon), such as dyke, moor, fen, and marsh. Although it is not the intention of this section to list all possible types of wetland ecosystems, it is important to distinguish between the most common ones, as their hydrological and vegetational differences influenced

people's choice to interact with and exploit them (Gopal, 2009) (see also Ch. 3, under 'The Environmental Setting'). Mitsch and Gosselink (1993, 2000, 2007; see also Mitsch et al., 2009) discuss a number of different ecosystems, highlighting the various characteristics of each of them. For instance, they describe mires as any peat-accumulating wetland (mostly characteristic of the European continent), distinguishing between bogs and fens. While the former consist of peat-accumulating wetland (usually supporting *Sphagnum* moss), with no significant inflow or outflow, the latter receive some drainage from surrounding areas, and usually support marsh-like vegetation. Their formation is normally due to a low rate of decay of dead plant material, the resulting of an in-filled lake (terrestrialization), or by a process of waterlogging less wet mineral soils (paludification) (Dierßen, 2003). Peat formation is also favoured by factors that reduce metabolic activity of micro-organisms, such as water saturation in the uppermost peat layers (the unsaturated zone = acrotelm), especially in eutrophic areas, and climatic and edaphic parameters (e.g. low temperature, short vegetation periods, low nutrients, and/or low pH of the peat). One of the most important factors in the dynamic of mire formation is hydrology, which interacts with the main structural components, namely the living vegetation, the unsaturated zone (acrotelm), and the saturated zone (catotelm) (Money et al., 2009). If the influx minus efflux plus storage is equal to zero, then we have a general water balance. This balance varies between bogs and fens. In bogs the driving force of peat accumulation is the interrelation system between precipitation and evapotranspiration, whereas in fens the balance is very much influenced by surface flow and lateral and upwards percolation (see Fig. 1.8) (Baker et al., 2009; Dierßen; 2003; Dise, 2009; Streefkerk and Casparie, 1989). A type of bog that differs from the raised bog is the blanket bog. The drainage of water in blanket bogs (especially on hills and mountains) is impeded by leaching and iron pan formation, which results in the formation and coverage of peat (usually moss and heather) over an originally 'dry' surface (Hammond, 1981; E. Maltby, 2009).

Other types of wetland are: the bottomlands, which consist of lowlands along rivers (in most cases located on alluvial and periodically flooded floodplains); marshes, which are fresh or saltwater wetlands characterized by emergent herbaceous vegetation adapted to waterlogged soils; and reed swamps, that in Europe are dominated by *Phragmites*, as opposed to the North America swamps, where trees (e.g. beech, white cedar, and larch) and shrubs prevail. In North America, large amounts of wetlands, which include peatland and bogs (and sometime also fens) and are mostly found in sub-arctic regions, are also known as muskegs. There are finally lacustrine environments, often located in interfacing areas between wet and dry conditions. Here, vegetation as well as human occupation is very much influenced by the hydrological character of the lake, which itself is the result of autogenic and allogenic factors; the latter influenced by large catchement areas (see also Ch. 6, under 'Palaeoclimatology: Climate Change and Hydrological Imbalances').

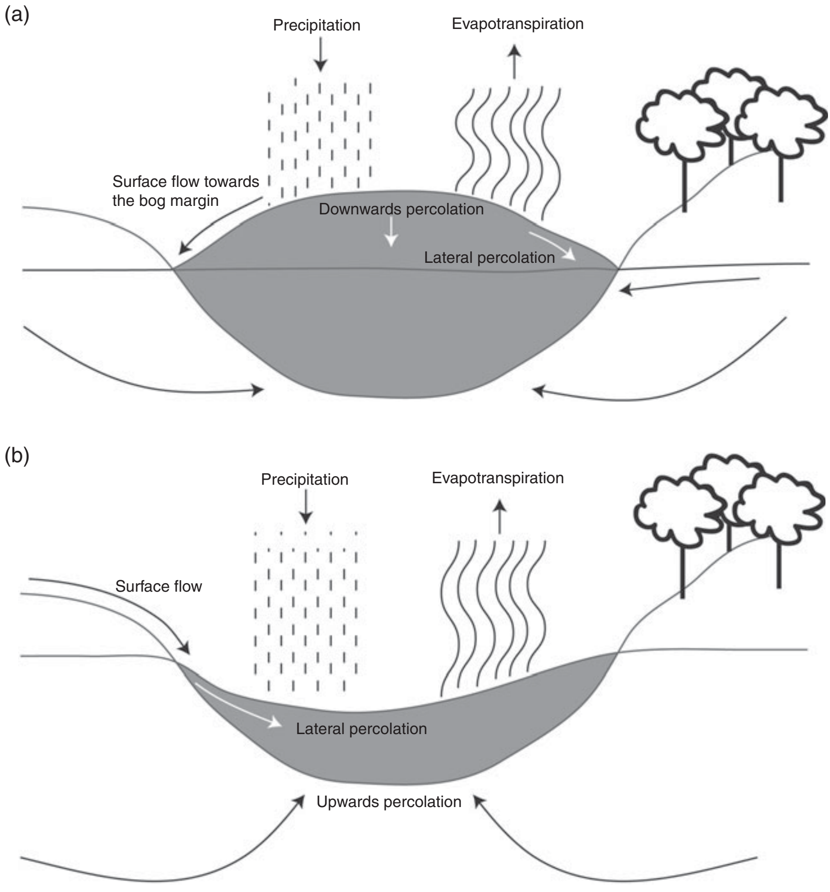


Fig. 1.8. Hydrology of bogs (a) and fens (b) in relation to peat formation. (*Graphic*: Ben Jennings)

The function of wetland ecosystems is mostly determined by hydrological processes. Surface and surface-water movement within the wetlands also determines the nature of water storage. Hydrological conditions affect physical and chemical wetland properties, such as nutrient availability and pH (Verhoeven, 2009). A proper understanding of water hydrological processes and their interaction with wetland ecology is crucial to comprehending wetland formation and development. Factors such as water depth and the length of the inundation influence the nature of adaptation required by plants to colonize a wetland area (Baker et al., 2009). Variations in hydrological balance caused by (either or both) natural and human-induced factors may, therefore, have severe repercussions on the entire ecosystem. Recognizing these changing processes will certainly shed light on the complex and interwoven relationships between people and wetlands, hence leading to possible plausible answers as to

why specific ecosystems were preferred over others. It is therefore on a proper knowledge of past and present ecological functioning of wetlands that research projects, as well as successful conservation and protection management plans for the future, should be based (Money et al., 2009). Most important, however, is to comprehend how people responded to those dynamic transformations. Palaeoenvironmental evidence shows that any of the above-mentioned types of wetland ecosystem could have changed into any other type, within a very 'short' timespan. A morainic lake, for instance, could have become overgrown with vegetation and finally buried in several metres of peat, as much as a concave depression in the landscape might have been converted into a fully-fledged water basin. In other words, what was wetland once could have become dryland, and vice-versa. Coming across a well-preserved site in waterlogged conditions does not necessarily mean that we are dealing with a wetland site. Similarly, what might look like a badly preserved dryland site could have been part of a proper wetland ecosystem in the past. The distinction between wet and wetland sites is therefore pertinent to the study of people–wetlands interaction.

Wet or Wetland Sites?

Despite the fact that wetland archaeologists often tend to place waterlogged archaeological sites into the same category, there is certainly a difference between well-preserved objects found in water wells of dryland settlements (see Erkelenz-Kückhoven, Germany), and similar objects found in a peatbog. Yet, can a clear-cut distinction still be made, when the difference is not so obvious? Nicholas (2001: 263) lists coastal, lacustrine, and riverine/estuarine sites as wet sites, arguing, on the other hand, that sites found in existing swamps, marshes, or similar environments should be considered wetland sites. While admitting that considerable overlapping occurs between the two types, he still maintains that there are significant differences (p. 263). It is true that wetland sites are 'defined by the relationship between people and the particular type of ecological setting' (p. 264) (e.g. swamps, marshes, moors, etc.), and wet sites by 'the association between artefacts and the context of preservation' (p. 265). However, in the majority of cases the distinct separation is almost impossible to achieve. For instance, although we may be tempted to classify the prehistoric lacustrine settlements of the Circum-Alpine region as wet sites, a close look at palaeoenvironmental reconstructions show a broad wetland interface between the lake and the dryland, represented by a variety of wetland-looking environments. People's equal interaction with the lake, the surrounding marshlands (or swampy areas), and the drier inland environments is clearly demonstrated by the archaeological assemblages. The same could be argued for the weirs/fish-traps within estuary environments (also

listed as wet sites). In fact, not only were fresh and/or saltwater marshlands situated nearby, but in many cases, within the entire estuary system, making the distinction, once again, very difficult. There are, however, examples where the distinction is absolutely obvious, as in the case of the *Linearbandkeramik* (LBK) Erkelenz-Kückhoven water-well (Weiner, 1994). Despite its excellent preservation in a water-saturated context, it is unmistakably obvious that the site had nothing to do with wetland environments. The construction of the well and its stratigraphic deposits has, however, provided invaluable insights into the hydrological situation of the area in relation to water-table fluctuations. Notwithstanding this unambiguous example, recent research has more and more confirmed that in most cases a clear-cut division between the two types is not so straightforward. At the same time, though, it is incorrect to deny the existence of the two types of site, or to question the importance of distinguishing between them, as this may have significant implications for archaeological thought. Instead, an accurate reconstruction of the site's palaeoenvironment and its contextualization into a wider geographical setting will not only avoid counterproductive conclusions, but may even highlight the distinction automatically.

MORE THAN JUST GOOD PRESERVATION

The significant difference between wetland and dryland contexts in preserving organic material is pointed out in almost every wetland archaeology publication. Although it is clearly understood that the level of preservation varies considerably from place to place even within water-saturated conditions (depending on a number of factors, such as climate, hydrology, and soil and water chemical composition), the difference between wet and dry environments is still very pronounced in terms of specific organic materials. For instance, while there is virtually no difference with flint/stone, glass, pottery, and charcoal, the discrepancy increases significantly with plants, wood, skin, basketry, invertebrates, and textiles (Fig. 1.9). It is also interesting to notice that with bones, the waterlogged effect can, on the other hand, have negative repercussions. In fact, in low pH peatbogs, the preservation of bone material is very limited, unlike that of skin, which survives very well (see Ch. 4, under 'Bog Bodies'). A totally different situation is present in minerogenic water-saturated contexts (e.g. the Circum-Alpine region lake-dwelling, and/or coastal environments), where bones are well-preserved, but other bodily tissues (e.g. skin, hair, etc.) are not (Corfield, 2007). One should therefore be careful in taking for granted the properties of waterlogged environments in preserving organic material, as not only do they differ from context to context, but, influenced by both natural and human-induced factors, they also change through time (see also Ch. 5 and Fig. 5.17).

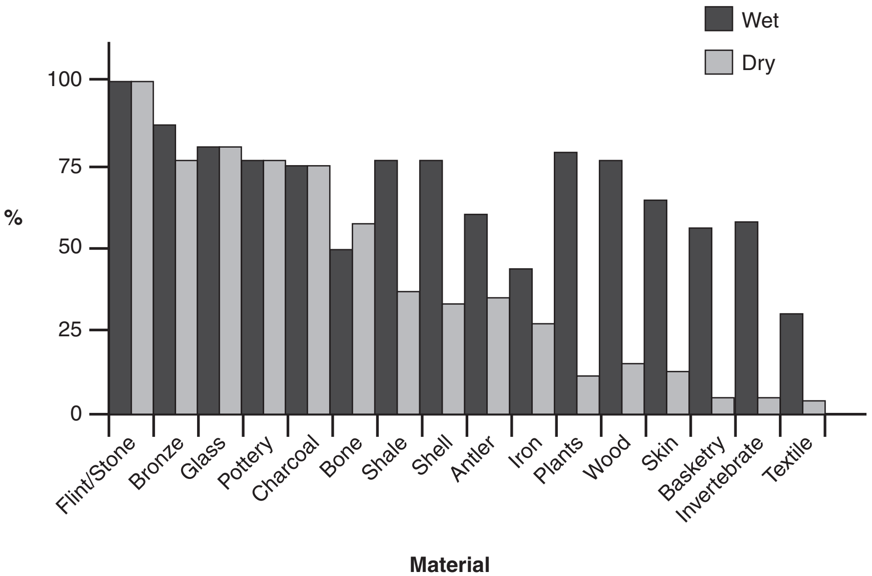


Fig. 1.9. Preservation of different materials in wet and dry conditions (*Graphic*: F. Menotti)

The remarkable findings of wetland archaeology often make headlines in newspapers or in the news, all over the world (e.g. the Circum-Alpine region lake-dwelling, the Sweet Track and Seahenge in England, Biskupin in Poland, Windover and Ozette in the United States, and the Kohika *Pa* in New Zealand—see also Ch. 9). The real strength of the discipline is, however, quite often overlooked. It is, in fact, what is *not* seen in wetland archaeological assemblages that provides us with the most valuable insights. For example, it is the strategic location of Early Holocene (e.g. Mesolithic) wetland sites in the Baltic Sea region that hold the key to a better understanding of the various stages of formation and development (from the Baltic Ice Lake to the Littorina Sea) of the Baltic Sea (Bjork, 1995; Timofeev et al., 2005). Similarly, underwater sites in the Öresund between Sweden and Denmark (Fischer, 1995; L. Larsson, 2001), and those at Bouldnor Cliff, on the north-western coast of the Isle of Wight (Momber, 2007) tell us more about the inexorable process of sea-level rise after the Last Glacial Maximum, the enormous amount of land lost to the sea (e.g. the Doggerland—see Fig. 2.2), and the serious implications it had on people's occupational patterns in northern Europe and the British Isles (Bailey, 2007; Shennan and Andrews, 2000; Waddington et al., 2003). Other Mesolithic sites in northern Europe and Scandinavia suggest that the highly dynamic landscape, which resulted from the continuous rise of the sea level, should not always be regarded as negative, for it has been confirmed that it offered plenty of new opportunities to coastal as well as inland communities

(Bell, 2007; L. Larsson, 1998, 2001). This is also proved by recent anthropological studies on modern social groups living in seasonally flooded environments of the Amazon Basin (M. Harris, 2000). Finally, wetland sites, which were occupied within the transitional period, Mesolithic-Neolithic in Europe (e.g. the Deby 29 and Dunka in Poland), provide invaluable insights on the hotly discussed process of Neolithization. It was, in fact, thanks to such occupations that a more precise distinction between the use of pottery and the introduction of agriculture in north-western Europe as evidence of the Neolithization process, could be established. In some parts of north-eastern Europe the use of pottery is still regarded as the beginning of the Neolithic, but that does not necessarily mean the beginning of cultivation (Timofeev, 1998; Zvelebil and Lillie, 2000). The often biased description of Mesolithic communities (Pluciennik, 2008) is challenged by high-resolution archaeological evidence, which shows a fairly different and rather unconventional image of the Mesolithic way of life.

Wetland archaeological assemblages also contain invaluable proxy data for palaeoenvironmental reconstructions (see Ch. 6), which offer the possibility of monitoring climatic variation, as well as change in vegetation, for the past several millennia. This evident environmental variability is clearly embedded in the rich wetland archaeological assemblages. For instance, the poor quality of wooden material used to construct the houses and the adoption of peat as fuel for the fireplace at the Bronze Age settlement of Bjerre 2 in Denmark, indeed shows a lack of availability of wood resources, which is also confirmed by palynological analyses (Andersen, 1995; Bech, 1997: 6–8).

Well-preserved objects are not only aesthetically pleasing, but also offer invaluable insights into the various degrees of people–wetlands interactions. These, in other words, provide us with the so-called 'insider's view', making us question inadequate and often biased representations of the past everyday life in the wetlands. For example, the exploitation of the wetland ecosystems did not only have an economic aspect, but there was also a sacred connotation. In fact, a variety of objects ranging from rich war booties (e.g. Skedemosse, Sweden) (L. Larsson, 1998) to simple agricultural tools were deposited in almost every bog of northern Europe, the swampy areas of New Zealand (Irwin, 2004*b*), and even the *cenotes* of Mesoamerica (Coggins, 2001). The northern European bog bodies have also revealed a sinister aspect of beliefs linked to sacrificial offerings (van der Sanden, 1996), whereas mortuary practices in North America (e.g. Windover, Florida, United States) (Doran, 2002) show the importance of the wetlands in perpetuating life after death (see also Ch. 4, under 'Sacred Practices and Beliefs' and 'Bog Bodies').

Another example of how effective well-preserved organic material can be comes from the northwest coast of North America. Here, the large amount of highly diverse basketry has proved crucial for the identification of cultural continuity and/or discontinuity (Bernick, 1998). In fact, cladistic analyses on the various stylistic

divisions of basketry remains have helped recognize cultural differences as well as similarities amongst the different local communities, even making it possible to trace change (or lack of it) through space and time (Croes, 1995, 1997). A combination of archaeological and ethnographical studies has also shown how basketry artefacts were closely integrated throughout people's lives, accompanying them through their various stage of physical and social development from birth to death (Croes, 2001) (see also Ch. 4, under 'Basketry and Cordage').

It is important finally to point out that regardless of how remarkably well-preserved artefacts found in wetland contexts might be, such objects are of no use if we fail to contextualize the site(s) where they were found into a wider sociocultural and geographical dimension. A typical example is the lake-dwelling tradition of the Circum-Alpine region. Because of the peculiarity of their material culture (and the limited possibility of comparing it with non-lacustrine sites of the region), it was initially thought that they could have been part of particular communities, which were culturally different from the neighbouring 'inland' populations. Once the lake-dwelling settlements were placed in a wider geographical context, the theory was promptly rejected.

As discussed throughout Chapter 8 (see also 'Why the Isolation?' below), the urgency of contextualizing wet and wetland archaeological finds has become a priority matter within the discipline. The wide discrepancy in contents of organic materials between dryland and wetland archaeological assemblages is striking. Paradoxically though, this tends to isolate wetland archaeology rather than facilitating its integration into mainstream archaeological thought. Instead of pointlessly highlighting the differences, we should try to bridge them. As proved by recently carried out projects, a very effective tool to achieve this goal is multidisciplinary research. The results of various scientific analyses usually performed in wetland archaeological projects, have been used in fields of research well beyond archaeology (see Ch. 6). Interestingly enough though, an even greater paradox is that those results often end up being 'recycled' by mainstream archaeology. This proves once and for all that good preservation of organic archaeological remains can certainly be seen as an advantage, rather than a pretext of irreconcilable separation.

WHAT YOU SEE IS NOT ALWAYS WHAT YOU GET

Finding archaeological organic material buried in waterlogged conditions is not always as straightforward as it might seem. In fact, the majority of the most sensational wetland archaeological discoveries have been made by chance (see, for instance, Sweet Track, Star Carr, Flag Fen in England, Key Marco and Windover in the United States, the Tollund bog body in Denmark, most of the lake-dwellings in the Circum-Alpine region, Biskupin in Poland,

and Alvastra in Sweden, to mention but a few) (Coles and Coles, 1996). Detecting waterlogged organic material (e.g. wooden structures) beneath the soil surface is extremely difficult, as they become very soft and acquire the same consistency as the matrix (soil or peat) around them. As a result, conventional geophysical survey devices, such as Ground Penetrating Radar, become ineffective at identifying them. There are, however, non-destructive survey methods such as the Swath Bathymetry Sonar for underwater survey, and Spectral Induced Polarization for waterlogged terrains, which, used in conjunction with more conventional techniques (e.g. auger survey, aerial photography, Electromagnetic Survey, Multi-Spectral Scanning, Magnetic Susceptibility Survey, and Caesium Vapour Magnetometer), have proved to be reasonably successful (C. Cox, 1992; Gostnell, 2005; Weller et al., 2006) (see Ch. 5).

The difficulty in identifying waterlogged organic remains is mirrored by the complexity of retrieving them once they have been located. Their delicate nature requires particular excavation techniques, which are rather different from those of conventional dryland archaeology. Water-saturated terrains entail a different excavation approach, which depends upon the morphology, hydrology, and composition of the soil sediments in which the archaeological remains are concealed. As walking on wet terrains during excavation may damage the archaeological material, suspended walkways and scaffolding structures may be used in peatbog environments (Coles and Coles, 1986; Schlichtherle, 2002, 2004). Since a fairly large number of wetland sites are submerged, specific underwater excavation techniques used in shallow-water lakes and other freshwater basins have been developed in order not to damage their valuable contents. For instance, techniques such as the 'water-jet pipe' and the more conventional 'vacuum' method have been developed specifically to cope with compact clayish lake marl, and much softer sediments, respectively (Hafner, 2004; Eberschweiler et al., 2006). Where the water is too shallow, scuba-dive excavations are replaced by the caisson technique, whereby the site is contained within double-lining metal sheets, all the water drained by vacuum pump, and the area subsequently excavated as a normal wetland site (Ramseyer, 1988; Zwahlen, 2003) (see Ch. 5).

One of the drawbacks of wetland excavations is that one can never know exactly what to expect. What is assured is that, owing to their exceedingly delicate structure, waterlogged organic objects can be destroyed in the blink of an eye if care is not taken. Conservation methods are therefore crucial in order not to waste what nature has been preserving for a long time (see also Ch. 5, under 'Conservation').

Conservation is meaningless, however, if we do not preserve the natural environment that holds those delicate remains in the first place. Since we do not often know what lies beneath the surface, preservation is once again an arduous task. However, the prevention-oriented attitude of most management policies has facilitated the development of quite effective protection techniques in

wetland environments in the past two decades. Methods such as the stabilization of water-tables (e.g. redox potential) used in waterlogged terrains (marshlands, swamps, peatbogs, etc.), and anti-erosion measures (geo-textile blankets, protective enclosure, etc.), applied on lake shores, river banks, and coastal areas, have become an essential part of wetland heritage policies in a number of countries worldwide (M. Cox et al., 1995, Hafner et al., 2006, Ramseyer and Roulière-Lambert, 2006).

One of the strengths of wetland archaeology is its well-preserved micro-organic remains (both flora and fauna). This is why, once wetland archaeological excavations have started, no matter how glamorous the artefacts might be, the greater thrill is more likely to be brought about by what, in lay people's eyes, could appear completely useless. Not only do such remains allow archaeologists to reconstruct palaeoenvironments as well as socio-economic aspects of ancient communities, but they also trigger an invaluable multidisciplinary collaboration between a myriad of different disciplines.

In fact, although the three most inseparable subdisciplines of archaeology linked to wetland archaeology are archaeobotany, archaeozoology, and geoarchaeology (including micromorphology), the richness of micro-organic remains offers perspectives of research to a number of other disciplines. The invaluable aspects of this multidisciplinary work are twofold: the obtaining of specific results from the individual disciplines, and finding that they serve as proof or disproof of other disciplines' outcomes. It is indeed with this synergetic effort between the various disciplines that higher precision and accuracy of results is achieved (see, as an example, Box 3.1, Ch. 3).

The high number of plant remains yielded by waterlogged archaeological sites, makes archaeobotany one of the most active disciplines in a wetland archaeology project (Jacomet, 2004, 2007). Where minerogenic and calcareous waterlogged deposits allow the preservation of bones and antlers, archaeozoology too has a full-time job trying to shed light on people's relationships to animals (hunting and domestication) and their economic value within the community (Arbogast et al., 2001; Noe-Nygaard and Hede, 2006; Schibler, 2008). A currently developing research area, linked to both archaeobotany and archaeozoology, is ancient DNA studies (Gilbert et al., 2005). Domestication and migration issues of both animals and plants are the top priorities of the discipline within wetland archaeology at the moment (Dobney and Larson, 2006; Schlumbaum et al., 2008; Zeder et al., 2006). Another subdiscipline that is fully integrated within wetland archaeological research is geoarchaeology, with a special emphasis on macromorphological analyses of depositional processes (Schiffer, 1987). The discipline also works closely with archaeobotany and palaeoclimatology, as they are all crucial for a better understanding of environmental variations (Lewis, 2007; Magny, 2004*a*). More recently, palaeoenvironmental research has also integrated insects and parasites studies

to explain episodes of climatic and environmental variability (Elias, 2010; Greenwood et al., 2006; Whitehouse, 2006) (see Ch. 6).

The large amount of well-preserved timber found in waterlogged contexts has also contributed to the development of one of the most precise dating techniques in archaeology: dendrochronology. In fact, some of the longest and most reliable sequences in Europe have been constructed almost entirely from lake-dwelling settlement remains (e.g. the southern Germany sequence, reaching back 11,000 years) (Baillie, 1995; Becker, 1993; Billamboz, 2005). Dendrochronology is used not only for dating, but, in collaboration with archaeobotany and geoarchaeology, also for palaeoenvironmental reconstructions and forest management (Billamboz and Köninger, 2008). Where tree-ring sequences are not available, dendrochronology is combined with radiocarbon dating to create floating sequences using the wiggle-matching technique (Bronk Ramsey et al., 2001; Galimberti et al., 2004). The symbiotic collaboration between the two dating techniques continues, as dendrochronology is often used to calibrate radiocarbon dates (Reimer et al., 2004). A similarly precise dating method, strictly linked to wetland environments and also used for radiocarbon calibration is the lacustrine varve technique. Like tree-rings, varves also offer invaluable insight into palaeoclimatic and environmental variations, which, in optimal conditions, can extend much farther back than dendrochronology (Kitagawa and van der Plicht, 1998) (see Ch. 6).

With such a vast range of research topics, one may think that wetland archaeology occupies a leading position within mainstream archaeology. Yet, the difficulties of finding, excavating, and analysing waterlogged archaeological sites ensure that the life of a wetland archaeologist is not an easy one. It is certainly true that 'what you see is not always what you get'. A the same time though, it is indeed from 'what is difficult to see that wetland archaeology makes the most'. The strength of the discipline is, in fact, that it offers research possibilities to a number of other disciplines, whose results are useful not only to archaeology itself, but to a much wider field of research, encompassing the humanities and natural sciences. Ironically though, despite this multidisciplinary character, wetland archaeology has tended to become more and more isolated within its own parental discipline. At this point two obvious questions arise: what causes this tendency, and is it felt everywhere?

WETLAND ARCHAEOLOGY AS ACADEMIC DISCIPLINE: DIFFERENT PLACES, DIFFERENT PERCEPTIONS

Wet and wetland archaeological sites are difficult to locate, complicated and exceedingly expensive to excavate, preserve, conserve and analyse, and the

results are often not too aesthetically appealing to the eye of the public. It is therefore not surprising if wetland archaeology has been having trouble integrating into mainstream archaeology. But are these shortcomings the real reason for the isolation? And, most importantly, is this isolation a worldwide phenomenon? In order to answer these questions, we should step back once again to the very beginning of wetland archaeology, and more precisely when the 'new' trend of searching for, and excavating wetland sites in rather inhospitable environments started. It is most of all important to see how this new way of doing archaeology was accepted in different countries. In other words, we need to understand how different research traditions acknowledged and integrated (or not) this new archaeological trend.

At the time of the first lake-dwelling discovery and the subsequent 'lake-dwelling rush', Europe was experiencing a revival of interest in the past. It was the time of great archaeological discovery, but the main focus was essentially placed upon the Roman world, the south-eastern Mediterranean region, Egypt, and Mesopotamia. All of a sudden the lacustrine areas of central and northern Europe also became the centre of the attention. For the first time, those seemingly uninviting wet environments were transformed into interesting and (why not?) lucrative areas. However, once the lake-dwelling rush subsided, the focus of archaeological research shifted back to more conventional dryland archaeology. This is not to say that wet/wetland site discoveries ceased completely (see for instance Biskupin, Poland in the early 1930s, and Star Carr, England in the late 1940s) (J. G. D. Clark, 1954; Piotrowski, 1998), but the wetlands reverted to being gloomy and uninteresting areas. In the 1960s and 1970s, however, a significant series of discoveries, brought about by new economic development, was made. The development of wetland archaeology was facilitated not only by the new discoveries, but most importantly by the advent of New Archaeology (Binford, 1983). The environmental-deterministic and processual orientation of New Archaeology perfectly suited the waterlogged archaeological assemblages, rich in organic remains.

It was thanks to the seminal work of John and Bryony Coles in the Somerset Levels in the 1970s and 1980s that wetland archaeology as an academic discipline was born. The discipline was soon accepted all over the world, international conferences under the auspices of the Wetland Archaeological Research Project (WARP) were organized, and even a new journal (*Journal of Wetland Archaeology*) was founded, at the very beginning of the twenty-first century (J. M. Coles, 2001*a*). Despite this international success, the discipline began to be criticized for becoming more and more isolated from mainstream archaeology. Interestingly enough, this alleged isolation was (and still is) a uniquely British phenomenon (Louwe Kooijmans, 2007).

Why the Isolation?

The isolation, or more precisely, the failed integration of wetland archaeology into mainstream archaeology in Britain is the result of a series of interwoven factors, linked to both the discipline's approach to research and the process of theoretical development in archaeology during the 1980s (Trigger, 1989). Because of the remarkable state of preservation of organic archaeological artefacts found in waterlogged contexts, wetland archaeologists tended to orient their reasoning in functionalist and environmental-deterministic directions. They thought, in other words, that the abundant and detailed archaeological evidence would speak for itself, with no need for any theoretical elaboration. As a result, most publications were mainly simply descriptive, without any sociological and anthropological theory-related reasoning. This attitude towards archaeological research was particularly encouraged by the processual orientation of New Archaeology from the 1960s onwards. It has to be pointed out that this processual approach to archaeological thought was not confined to Britain, but also encompassed the United States and a large part of Europe. So, why was (and still is) the criticism towards wetland archaeology (which led to isolation from mainstream archaeology) more accentuated in Britain than anywhere else? The cause is most likely to be found within the particular development of archaeological theory in the 1980s, and more precisely with the formation of post-processual archaeology (Hodder, 1982; Shanks and Hodder, 1998). Promoters of this new theoretical trend criticized processualists for being interested mainly in processes and environmental issues, rather than in people and their social world. Wetland archaeology and the mainly descriptive nature of its publications were therefore used as examples to prove that point (Tilley, 1991). Although it would be incorrect to generalize too much, this criticism towards wetland archaeology proved to be constructive, and the attitude to research began to be modified, with people and their social lives becoming more and more a part of the wetland archaeological rationale (O'Sullivan and Van de Noort, 2007; Van de Noort, 2004*b*; Van de Noort and O'Sullivan, 2007).

Beyond the British Isles

The above-mentioned shortcomings of wetland archaeology, as already noted, were certainly not confined to Britain; they were present elsewhere, especially in continental Europe. If this was the case, then why did not similar criticism arise in other countries as well? There are two main reasons: first, post-processual archaeology's reaction to the processual way of archaeological research was not as significant as in Britain; and secondly, wetland archaeology as a distinct subdiscipline of archaeology never really developed in

continental Europe. In fact, the deeply rooted archaeological research tradition of most of mainland Europe's countries has not only prevented the spread of post-processual thought, but has also hindered the development of wetland archaeology as a separate subdiscipline of archaeology. Hence, wetland archaeological excavations and projects were simply considered as part of conventional archaeology. A confirmation of this comes from the term 'wetland archaeology' itself, which in some countries, despite a long tradition of wetland archaeological research, does not even exist. In the Netherlands for instance, archaeologists involved in wetland projects admit borrowing the English term for their publications. A similar situation is found in Denmark, where the literal translation of 'wetland archaeology' in Danish—*vådbundsarkæologi*—sounds a little 'homemade' (Jens-Henrik Bech, pers. comm. 2010). In Germany, France, and Italy, notwithstanding their brave attempts to create their own terms—*Feuchtbodenarchäologie*, *archéologie des milieux humides*, and *archeologia delle zone umide* respectively—the discipline as a separate branch of archaeology has not as yet been established. Therefore, since there has never been any separation, no reintegration is needed (Louwe Kooijmans, 2007: 96).

No need of integration does not, however, imply a full integration, nor, most importantly, a proper consideration of the great potential of wetland archaeological research. In fact, all the shortcomings of wetland archaeology in Britain and Ireland mentioned by Van de Noort and O'Sullivan in *Rethinking Wetland Archaeology* (2006) are very much present in a number of other countries, and, there too, the suggested remedies are needed.

In North America the situation is rather different. Although, wet/wetland archaeological sites have become more and more part of mainstream archaeology, wetland archaeology as a subdiscipline of anthropology/archaeology has not developed. Neither Canada nor the United States see the palaeoenvironment as a subject of archaeological investigation, but rather as a context for understanding the cultural past; and this is probably the reason why wetland archaeology has not fully been accepted as an academic discipline. A similar situation can be seen in other parts of the world such as Japan, Australia, and New Zealand, where, however, thanks to the numerous wetland archaeological projects and publications, the discipline is increasing becoming part of the academic discourse of archaeology.

Although reintegration of wetland archaeology into mainstream archaeology may not be needed everywhere, integration certainly is. As discussed in Chapter 8, the long-overdue process of making wetland archaeological research an integrated part of the general archaeological thought has already started, and recent results have shown the great potential of the subdiscipline. We do not know whether wetland archaeology will develop as a fully fledged discipline everywhere. What has become clear, however, is that it will never be able to survive without a full integration into a much broader archaeological discourse.

A PROGRESSIVELY DRIER FUTURE: TO KNOW IS TO PRESERVE!

The way the general public is made aware of the rich wetland cultural heritage, and the importance of protecting it, are two crucial aspects of wetland archaeological research. The disproportionate emphasis placed upon scientific explanations has made it difficult for laypeople to appreciate the real value of wetland cultural heritage. Popular archaeology publications have made the effort to bridge the gap between academic research and the public, but in many cases scholars have not been particularly enthusiastic about 'too simplistic' explanations, for they may reduce the scientific value of the archaeological rationale. Remarkable discoveries have, however, triggered the interest of the public, and the media have taken advantage of this situation straightaway. In fact, TV programmes and documentaries based on sensational discoveries have always attracted the attention of a large audience (Leuzinger, 2008). Despite the fact they have often been criticized by professional archaeologists, these programmes have contributed greatly to making people aware of wetland ecosystems and their rich cultural heritage. A noteworthy effort to inform the public of the importance of wetland archaeological remains has been made by open-air museums. Their pedagogical character has been able to meet the visitors' expectations, encouraging people to become fully immersed in a past-like environment, artificially reconstructed on the basis of reliable archaeological evidence (Schöbel, 2004*b*, 2006*b*). Notwithstanding the possible imprecision of those replicated environments, they nevertheless allow the visitors to become part of the setting (Collins, 2008; Schadla-Hall, 2004) (see also Ch. 9, under 'Perceptions of (Re)constructed Pasts'). This, together with the hands-on archaeology experience (often part of the setting), facilitates the assimilation of complex information, helping people to remember it for longer. Open-air museums are certainly more aware of people's demands, and therefore more prepared to pay attention to their response (Hooper-Greenhill, 1996, 2007). As a result, ineffective teaching methodologies can be modified constantly to meet the audience's expectations. Surprisingly enough, it has been proved that this constructive interaction between experts and visitors is not only advantageous to the latter, but it offers invaluable insights to the former as well.

As the sub-heading of this section implies: 'to know is to preserve!' Hence, informing the public about the importance of the wetland cultural heritage should also include raising their awareness about the urgent need to protect it. It may seem a paradox that wetland environments, which preserve organic archaeological remains so well and for so long, are disappearing at an exceedingly fast rate (J. M. Coles, 2001*b*; Godwin, 1978; Nicholas, 2001). Notwithstanding the efforts of archaeologists and international organizations

(see Ch. 9, under 'Safeguarding Wetlands' Archaeological Heritage') to emphasize the importance of preserving the wetlands, the continuous reduction of these delicate ecosystems is still alarming. Significant measures to prevent this inexorable destruction have certainly been taken (see Ch. 9, under 'Protective Scheme Implementations: Successful Initiatives') (Coles, 2004; Fischer et al., 2004; Ramseyer and Roulière-Lambert, 2006). Yet the need for more integrated management is still very urgent. As discussed throughout Chapter 9, in order to tackle the problem, it is necessary to identify the convergences between concerns of cultural heritage and those of other biological values that are vital for the conservation and sustainable use of the wetlands. A solution would be to address all these values in active legislative instruments that are appropriately uttered within local, national, and international legislations. It is furthermore critical that all the parties involved in wetland heritage managements accept all the different values in a constructive way, in order to resolve conflicting management priorities (Olivier, 2001, 2004; Olivier and Van de Noort, 2002). It is important to be realistic and recognize the wellbeing of the entire community as the main concern, rather than prioritizing single individualistic aspects. Flexibility is essential when making strategic management decisions.

It has furthermore become evident that protecting our cultural and natural environments is not always about preventing change, but rather managing it. Management strategies should be the result of synergetic collaboration between archaeologists, environmentalists, and governing authorities (which of course includes the consensus of the general public), and this can only be achieved by continuous constructive interaction and communication. It should be accepted that no matter how hard it is resisted, change may be inevitable sometimes. Collaborative work should therefore be directed more towards familiarizing people with the unknown; trying to prevent the unexpected might lead to more unpleasant surprises. If, on the other hand, it is known what to expect, it might then be easier to face it.

Finally, people need to be convinced that protecting their cultural heritage is no longer the job of a few experts, but requires the full involvement of the whole of society, and in all possible spheres. Declining responsibility is no longer an option in the achievement of positive results.

CONCLUSION

It is perhaps a paradox that such an international and multidisciplinary research area as wetland archaeological studies has been having problems in being fully integrated into mainstream archaeology, and/or in developing into a fully fledged discipline. Aspects that should be advantages for the development and integration of the discipline have turned out to be obstacles. It is also incredible

that in some cases the results obtained by wetland archaeology are more appreciated within other disciplines and areas of study than within archaeology itself. However, as is discussed in this chapter and indeed throughout the book, wetland archaeological research has been changing significantly in the past two decades or so. Shortcomings and prejudices towards the discipline have been faced and solutions found. Wetland archaeology is, however, facing an even bigger challenge at the moment, which extends far beyond archaeology and indeed the entire academia. Environmental change is affecting all wetland ecosystems, which are disappearing at an alarming rate, taking with them our cultural heritage. Wetland archaeology alone stands no chance of success in preventing this inexorable destruction. This is a job for the entire human society—wetland archaeology can provide only some of the tools to carry it out.

2

People–Wetlands Interactions through Space and Time

INTRODUCTION

People have always been attracted to wetland environments. It might have been for sheer necessity (water sources, readily available subsistence resources, defence, etc.), or for more elaborate socio-economic aspects and beliefs. It is difficult to pinpoint exactly how long this relationship has been going on—probably since the dawn of humanity; but the older it is, the scantier archaeological evidence becomes. Due to the organic composition of a large number of artefacts (tools, weapons, etc.), and plant and animal remains, the chances that they are preserved are much higher in waterlogged environments than in dryland sites. The evidence of such remains, however, is restricted to specific geographical areas and limited to the period following the Last Glacial Maximum. Regardless of similarities of wet environments or climatic conditions, people–wetlands interaction has been neither similar, nor has it taken place in the same way worldwide. A specific approach adopted in one place at a particular time might have occurred earlier, later, or maybe never elsewhere. The interaction might have been driven by different needs, possibly linked to subsistence (food procurement), logistics (settlements), cosmological beliefs, or all of these. Using waterlogged archaeological evidence, this chapter explores the various ways people interacted with the wetlands, and in particular how and when they decided to settle within them, from sporadic seasonal camps in the Early Holocene to well-structured permanent settlements more recently.

The chapter has been divided into six main geographical areas: Europe, Africa, Asia, Oceania, North America, and Central and South America (not listed hierarchically, in order of importance, but simply geographically, from Greenwich, 0° longitude, eastwards), which themselves have further divisions based upon the relevance of wetland archaeological sites in each specific region (see the World Map and Maps 1–6 at the end of the volume). Each region (or area) is considered chronologically, taking into account its

different conventional archaeological periodization, derived from the area's endemic archaeological evidence. Where possible, local cultural and chronological divisions are emphasized, while at the same time synchronic events in different geographical contexts are compared.

The chapter deals mainly with settlement sites (both seasonal and permanent), their geographical location, chronology, and patterns of occupation in relation to their contextual cultural and environmental transformations. It is of course understood that settlement sites encompass also a broad spectrum of features (from architectural characteristics of dwellings to specific material culture), which are themselves crucial for a full understanding of the people–wetland interaction process. Although they are sometimes mentioned in this chapter in order to complement the settlement description, these features have been grouped and systematically described in Chapter 4.

Starting from Europe, the reader is taken on an eastward journey, which will end up in South America. The reader is, for instance, given the chance to contrast and compare seasonal Mesolithic wetland camps in Scandinavia (L. Larsson, 2001), with those of the Early Jomon Culture in Japan (Miyaji, 1999); or to understand why the lake-dwelling tradition in the Circum-Alpine region has its origins in more southern latitudes (Schlichtherle, 1997*b*), despite drier environments. There might even be the chance to shed light on the fascinating question as to why Monte Verde (Chile) was occupied well before any other place in the Americas (Dillehay, 1989, 1997)—or was it?

EUROPE
(see Maps 1 and 1A–H)

It is maybe not surprising that the majority of archaeological wetland sites in Europe are found in northern latitudes. This is of course due to a colder and more humid climate than that of southern latitudes, which has favoured the formation of wetter environments (see Ch. 1). It is understood, however, that the more abundant evidence is not only linked to a larger number of wet ecosystems, and/or a higher degree of people–wetlands interaction, but also to a better level of preservation (see Ch. 5). In fact, it is the latter variable that often prevails.

The European section of the chapter has been organized chronologically from the Mesolithic to the Middle Ages. Although each archaeological period is supposed to cover the entire continent, there are areas in which wetland archaeological sites have not been found, and these areas, therefore, are not listed. The sites mentioned in the text do not appear in order of importance, but they follow a rather thematic pattern, which allows for useful typological

comparisons amongst synchronic, but geographically distant, occupations. In the case of the Mesolithic for instance, where the majority of sites are concentrated in the north, their chronological descriptions in relation to geography are not always relevant, whereas from the Neolithic onwards (and in particular during the transitional period Mesolithic–Neolithic), chronology follows specific geographical patterns, resulting from the process of 'Neolithization'. It has to be pointed out that the above-mentioned archaeological periods are not chronologically the same throughout Europe (see Fig. 2.1). A Neolithic site in central Europe may, for instance, be contemporaneous with a Mesolithic site in Scandinavia, as much as an Early Medieval settlement in Ireland could still be synchronic with a Late Iron Age village in the north-eastern Baltic Sea region.

As time elapses, people–wetland interaction becomes more and more complex, encompassing elements both sacred and profane. As early as the Neolithic, and in some cases even in the Mesolithic (L. Larsson, 2001, 2007*b*), the various activities within and between the wetlands reached far beyond sheer economy and subsistence levels; offerings and sacrifices were gradually integrated into the enculturation process of the European wetlands. Not only are the edges of lakes, rivers, marshes, peatbogs, and mires chosen as settling areas, but the wetlands (in particular peatbogs, mires, and fens) are themselves penetrated and explored more systematically. The construction of wooden causeways, trackways, roads, and even bridges begins in the Neolithic, reaching its maximum expansion in the later prehistoric to early historical times. And it is indeed during this period that we find the highest quantity of anthropogenic evidence in peatbogs, fens, and mires, represented by mainly wooden trackways often associated with offerings and, alas, even human sacrifices, possibly accompanied by executions (van der Sanden, 1996) (see Ch. 4 under 'Bog Bodies'). Either because of this negative connotation, or the need for more tillable land, wetland areas became less and less accepted in the post-Roman and Early Medieval times. It is, in fact, then that a portion of seemingly inhospitable wetlands began to be reclaimed for pasture and/or agricultural purposes. Lake shores, on the other hand, continued to be settled, especially in northern Europe (see for instance Irish and Scottish crannogs, as well as island settlements in the Baltic Sea regions), but the long-lasting lake-dwelling tradition in the Alpine region had already come to an end, since the beginning of the Iron Age (see below and Ch. 4). People–wetlands relationships in the Middle Ages still persisted, although settlements were now built a little further away. Land reclamation processes continued, and in some areas even intensified. Peat extraction for fuel started an inexorable process of destruction that in some parts of Europe has not even yet finished (see Ch. 9).

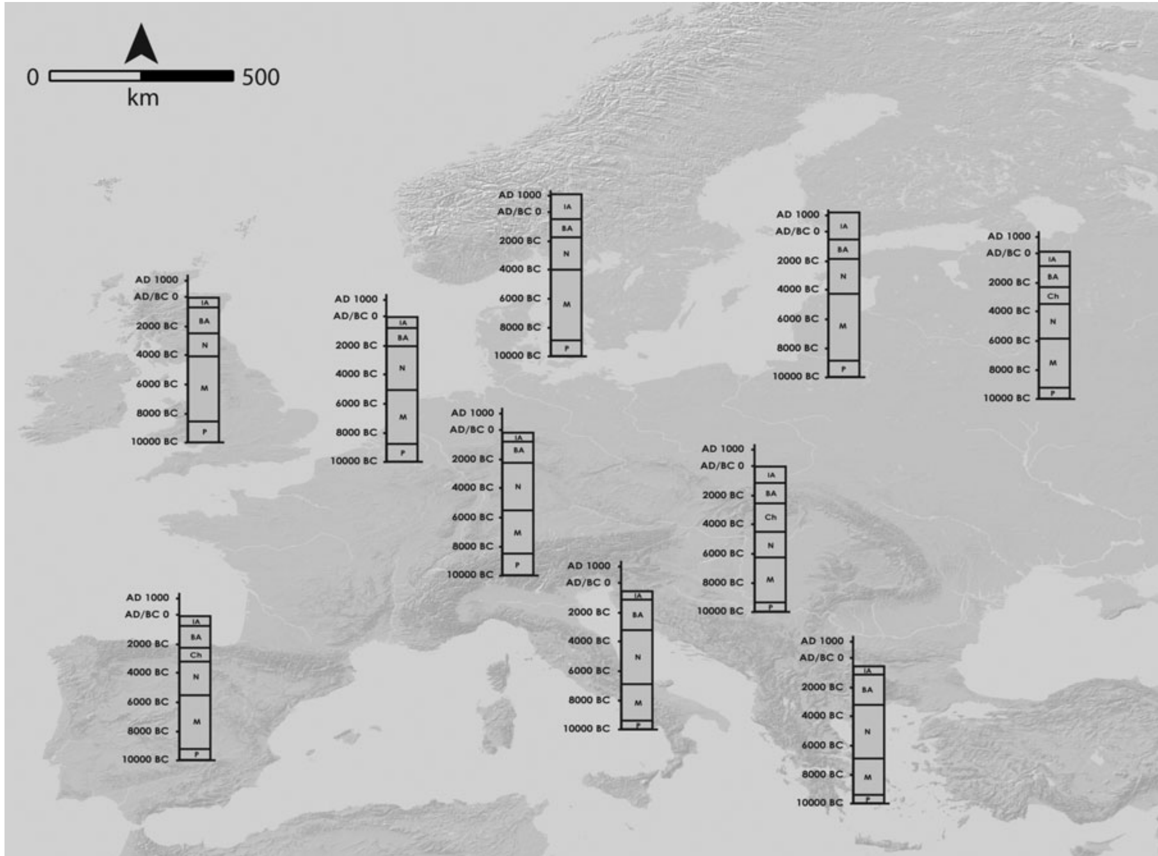


Fig. 2.1. Different chronologies in prehistoric Europe (Key: P = Palaeolithic; M = Mesolithic; N = Neolithic; BA = Bronze Age; IA = Iron Age. Note: dates are calibrated, but the locations of the bar charts are only approximate). (*Graphic*: Ben Jennings. Base map created using STRM data and ArcWorld River and Lake Overlay.)

Mesolithic

Although people's first interactions with the European wetlands started much earlier, it is mainly in the Mesolithic that we begin to find archaeological evidence in waterlogged conditions still remarkably preserved. Scandinavia and the regions surrounding the Baltic Sea is certainly one the richest areas in Europe in terms of waterlogged archaeological evidence in the Mesolithic. The Baltic region has also been one of the most environmentally dynamic areas since the end of the Last Glacial Maximum. As the ice retreated, a succession of water basins resulted: from the ice-dammed Luga, Pskov, and Vôrtsjarv, to the merging of the Ramsay Sea and the Baltic Ice Lake (Timofeev et al., 2005: 81). The Yoldia Sea formed afterwards, as the connection to the North Sea was established in *c.*8200 cal BC (Bjork, 1995). Isostatic uplift of central Sweden at the end of the Preboreal interrupted the link once again, forming the Ancylus Lake. Global eustatic sea-level rise, occurring in the second half of the eighth millennium cal BC, reopened the Öresund Strait (between Denmark and Sweden) and created the Littorina Sea (Timofeev et al., 2005). A combination of isostatic rebound in the north and eustatic rise of the sea level in the south contributed to shape the entire coastal area of the Baltic Sea throughout the Holocene. As a result, coastal Mesolithic sites (at the time of occupation) are today situated either inland (central and northern Sweden), or under water (southern Denmark and the German coast of the Baltic) (Hartz and Lübke, 2006; L. Larsson, 2001, 2007*c*). The post-glacial period was also characterized by a marked changed in climatic conditions and temperature, which reached on average 21°C in July (about 5°C higher than today), during the Climate Optimum of the Atlantic period (*c.*8000–5000 BP). A subsequent decline in temperature began as farming was being introduced in the region (*c.*4400 cal BC) (Zvelebil, 2006). These climate oscillations influenced the vegetation (especially in northern latitudes) which changed from a predominance of birch and pine in the Preboreal period (*c.*10300–9300 BP), to pine and hazel in the Boreal (*c.*9500–7500 BP), a mixture of oak, elm, beech, and lime in the Atlantic (*c.*8000–4500 BP), and finally, mixed broadleaved conifers in the Sub-boreal (*c.*4500–2500 BP) (Zvelebil, 2006: 179; Zvelebil and Moore, 2006). And it was indeed these striking environmental dynamics that predisposed and characterized the first colonization (see also Ch. 3) and the development of the various cultural groups of Scandinavia and the Baltic Sea in the Mesolithic.

Mesolithic cultural groups of the Baltic Sea region and surroundings can be ordered into two major chronological and geographical divisions, namely, the Early and Late Mesolithic in the western and eastern Baltic Sea. Those belonging to the Early Mesolithic are grouped thus: the Maglemose groups in the western Baltic Sea; and the Komornice, Neman, Kunda, Narva, Sandarna,

Table 2.1 Mesolithic cultural groups of the Baltic Sea

Early Mesolithic (10000–7500 BP)		Late Mesolithic (7500–5500 BP)	
Western Baltic	Eastern Baltic	Western Baltic	Eastern Baltic
Maglemose	Komornice	Kongemose	Janislawice
Sandarna	Neman	Ertebølle	Chojnice-Piénki
Hensbacka	Kunda	Lihult	Late Suomusjärvi
	Narva	Sandarna	Late Neman
	Veretie	Odesloe	Late Kunda
	Suomusjärvi	Lietzow	Late Narva

and Suomusjärvi cultures in the central and eastern Baltic Sea regions. Late Mesolithic cultural groups of the western Baltic Sea are the Ertebølle, Kongemose, Lihult, Oldesloe, Lietzow, Sandarna, and Chojnice-Piénki cultures; whereas the Janislawice, Late Neman, Late Kunda, Late Narva, and Late Suomusjärvi are part of the central and eastern areas of the Baltic Sea regions (Ballin, 2007; L. Larsson, 2003; Timofeev, 1998; Zvelebil, 2006; Zvelebil and Moore, 2006) (see also Table 2.1). Towards the end of the Mesolithic, the Funnel Beaker Culture (TBK) expansion had already reached the southern shores of the Baltic Sea, and started its penetration into Denmark.

There are a considerable number of Mesolithic wetland sites in Scandinavia and in the Baltic Sea regions, but as pointed out earlier, they are now either under water or (if inland) covered by thick peat deposits formed after the occupation (Jussila and Kriiska, 2006; L. Larsson, 1998). Due to the difficulty of finding them (see Ch. 5, 'Survey'), sites of the latter category are less numerous, and they are mainly located on the central-western coast of Denmark, south-western Sweden, and the Baltic shores of Germany. Despite the fact that a lot of sites consist of scattered and isolated finds, quite a few have been identified as proper settlements. A particularly fruitful area is the German coast of the Baltic Sea. Here, recently undertaken submarine archaeology projects have identified quite a few submerged sites, spanning from the Mesolithic to the Neolithic, and in particular, the crucial transition between the two periods. A location with a fairly large number of sites is the Wismar Bay (with Poel Island within it) in the Mecklenburg-Vorpommern, where more than twenty have been found. Amongst them, five in particular stand out for their remarkable findings: Jäckleberg-Huk, Jäckleberg-Orth, Jäckleberg-Nord, Timmendorf-Nordmole I, and Timmendorf-Nordmole II. All settlements are submerged at a depth varying from 1 to 9 metres and cover a time span of *c.*2500 years, from the Late Konglemose Culture to the Early Funnel Beaker Culture (Lübke, 2003, 2005, 2006; Lübke and Terberger, 2005).

Jäckleberg-Huk is one of the oldest submerged settlements in the Wismar Bay. It lies at a depth of 8.5 metres and consists of a cultural layer with various

fireplaces, well-preserved under a stratum of peat. The settlement was occupied between 6400 and 6000 cal BC, and the artefact assemblage shows similarities with the first phase of the Kongemose Culture, especially with the site of Blak II in Denmark (Hartz and Lübke, 1995; Lübke, 2006). At the time of occupation the settlement was located near a fresh-water basin, which is part of today's Wismar Bay. Interestingly, despite the proximity of the sea, no marine molluscs or fish have been identified, only a seal bone (Schmölcke, 2004, 2006).

Jäckleberg-Orth was occupied a little later (5950–5750 cal BC), and this is also corroborated by its less deep (7–8 metres) location. From the morphology of the terrain (sea bottom), the site must have been located on a small island just off the coast. As in Jäckleberg-Huk, there are quite a few land mammal remains (wild boar, red deer, roe deer, and aurochs), but no sea mammals. A further site on the Jäckleberg ridge is Jäckleberg-Nord. Its 6.5-metre deep location clearly shows a later occupation, between 5600 and 5100 cal BC (Lübke, 2005). In contrast to the previous sites, Jäckleberg-Nord has quite a high percentage of marine fish remains (Schmölcke, 2006).

Remains of a Middle–Late Ertebølle Culture fishing settlement (Timmendorf-Nordmole I&II) were discovered about 200 metres off the west of the Island of Poel. Structures of fish weirs and fish-traps, along with a number of wooden and antler artefacts were found in the oldest (Timmendorf-Nordmole II) of the two sites. A lack of pottery shows that the site belongs to the aceramic phase of the Ertebølle Culture, and this is also confirmed by a series of radiocarbon dates, between 5100 and 4800 cal BC (Lübke, 2005). In slighter less deep waters (2.5–3.5 metres) lies the later site of Timmendorf-Nordmole I. Here too, the archaeological assemblage is quite rich, consisting of bone and antler tools, fishing gear, wooden sticks (probably part of a fish weir), and parts of logboats (Labes, 2005). Unlike Timmendorf-Nordmole II, Timmendorf-Nordmole I has yielded ceramic remains, which show that, by then, the Ertebølle people had adopted the use of pottery. Archaeozoological analyses indicate a rich assemblage of wild fauna (fish, birds, and mammals), but, except for the dog, domesticated animals are absent (Lübke, 2006: 67).

Other relevant Mesolithic sites on the German Baltic Sea are to be found on the Island of Rügen (northern Mecklenburg-Vorpommern), and on the south-eastern Baltic coast of Schleswig-Holstein. Some of the most relevant sites on Rügen Island are, for instance, Baabe, Saiser, Breetzer-Ort, and Ralsviek (Hirsch et al., 2007). It is interesting to notice that in this region, due to a slight isostatic uplift process, Late Mesolithic and Early Neolithic submerged sites lie in shallow waters (mostly less than 1 metre). On the Schleswig-Holstein Baltic coast, in addition to the various submerged sites, a few settlements have also been found on land following the edges of former fiords, which were subsequently filled in by soil sediments and peat overgrowth. Except for the Ertebølle Culture site of Grube-Rosenhof (eastern part of the

Grube-Wessek valley) (Hartz and Lübke, 2004), most of the settlements of the Oldenburger Graben valley (e.g. Siggeneben-Süd, Oldenburg-Dannau, and Wangels LA 505) are of later date (see below).

Moving up the Baltic Sea coast of Denmark and its various islands, a nearly 30 year-old underwater archaeology research tradition has brought about the discovery of a substantial number of submerged Mesolithic sites (Engen and Spikins, 2007). These sites vary from scattered isolated finds to proper settlements, with clear evidence of either permanent or seasonal occupation. Amongst them though, only a few show traces of dwelling floors, and one of the best studied is the Møllegabet II settlement, situated in the narrow Møllegabet channel near the island of Dejrø. Here, the remains of a rectangular (approximately 5 × 3 metre) area consisting of a layer of bark resting on cross-laid branches and a fireplace have been discovered at a depth of 4.5 metres. Within the floor, there was a rich archaeological assemblage consisting of fish bones, flints, and nut and mussel shells. The site (dated to the early phase of the Ertebølle Culture, *c.*5500–5000 cal BC) included a logboat with a human bone of a 25-year-old woman. Because of the number of antler artefacts found adjacent to it, the dugout was identified as a boat grave (Rieck, 2003). Not far from Møllegabet II (about 20–30 metres north-east) another similar settlement, but with no house floor, has been located, at a slightly shallower level (2.3 metres). The site is called Møllegabet I; it is younger than Møllegabet II and belongs to the Late Ertebølle Culture, *c.*4500–4000 cal BC. What makes this occupation particularly interesting is the 60-metre long and 0.75-metre wide shell midden, which included very well-preserved antler tools, fish-hooks, flints, stone axes, and a peculiar wooden plate smeared with a coloured fatty substance, possibly related to the practice of body painting (Rieck, 2003: 57).

The best-known and most studied submerged Mesolithic site in Denmark still remains that of Tybrind Vig on the Lillebælt coast of western Fyn. The site chronology covers the entire period of the Ertebølle Culture (*c.*5500–4000 cal BC), and was abandoned in the very Late Mesolithic, and more precisely during the introduction of agriculture and animal husbandry in Denmark. Along with the large amount of beautifully preserved artefacts (flints, pottery, bone and antler tools, textiles, and various carved wooden objects), the site has also yielded the remains of at least three logboats (dugouts), with about fifteen paddles of which four are skilfully carved and decorated (see Ch. 4) (Andersen, 1985, 2011; Engen and Spikins, 2007).

Another area in south-western Scandinavia where particularly interesting submerged Mesolithic sites have been discovered is the Öresund Strait, the sound separating Zealand (Denmark) and Scania (Sweden). The submarine furrow in the strait corresponds to the former course of a river, along which a number of Mesolithic camps were inhabited. The sites are now between 6 and 20 metres under water, and they too (like those on the German Baltic Sea coast) followed the Baltic Sea transgressions from the Preboreal period

onwards. Of the Early to Middle Mesolithic sites found in the Öresund sound, the best preserved is that of Pilhanken, which lies at a depth of 7–8 metres and dates from approximately 8800 BP (Fischer, 1995; L. Larsson, 1998, 2001). It is interesting to note that, according to the Pilhanken site (and others), and evidence of the Early Mesolithic sea-level fluctuations (both of the North Sea and the Baltic Sea), considerable amounts of salt water from the North Sea did not penetrate the Baltic Sea until the end of the ninth millennium cal BC.

On the North Sea coasts of Scandinavia, and as far as the British Isles, underwater sites are not very numerous in comparison with the Baltic Sea, and they are also extremely difficult to find. Due to the post Late Glacial Maximum rise of sea levels, the land mass joining south-western Scandinavia and north-western Europe to the British Isles began to be flooded, and Late Palaeolithic as well as Mesolithic sites are now several metres under water (Fig. 2.2) (Bailey, 2007; Shennan and Andrews, 2000; Waddington et al., 2003). One of the crucial areas that is today completely submerged is the so-called Doggerland (Coles, 1998, 1999*a*), lying between the British Isles and Denmark. This

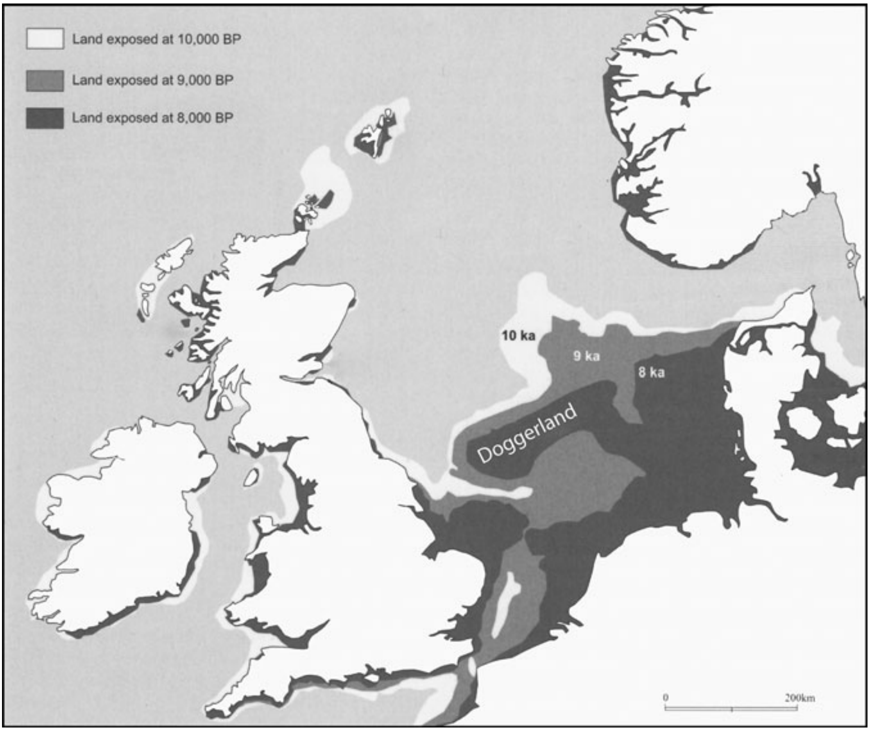


Fig. 2.2. Coastline of the North Sea in different periods, after the Last Glacial Maximum. (Modified from Waddington et al., 2003)

submerged land is crucial not only for the possible location of Mesolithic sites, but also for a better understanding of the somehow 'delayed' Neolithization process of the British Isles after being separated from mainland Europe during the final stage of the Mesolithic (see below).

Coastal, intertidal, and subtidal evidence of Mesolithic occupation in Britain is strictly related to geomorphologic processes, accompanied by constant sea-level fluctuations. The northern parts of the British Isles undergo isostatic coastal uplifting, while downwarping, inundations, and erosion occur in the south (Young, 2007: 16). As a result, it is not surprising that the majority of coastal (but dryland) Mesolithic sites are found in the north, and in particular in Scotland (Finlayson, 1995; Mithen, 2000; Russell et al., 1995; Warren, 2000). In the south, on the other hand, sites are located offshore and under water. A few of such sites have recently been discovered in the western Solent, the waterway that separates the Isle of Wight from mainland Britain (southern England). The sites are located along a former river valley, which was part of the main Channel river system active during the Pleistocene glacial periods. One of these Mesolithic occupations has been discovered at Bouldnor Cliff, on the north-western coast of the Isle of Wight. The site, which consists of lithics and a hearth, lies on organic peat immediately below a submerged forest (dated 8565–8345 cal BC), at a depth of 11.5 metres (Momber, 2007). About 7 metres of minerogenic deposits cover the organic peat, and it is only thanks to an active erosion process caused by the strong tides of the Solent that the site was exposed and subsequently discovered (Momber, 2000) (see 'Survey' in Ch. 5). As is the case of the Baltic Sea coast of Denmark and Germany, the submerged Mesolithic sites of the Solent also have the potential to enable the monitoring of the dynamic processes of environmental change through space and time, associated with sea-level rise. In fact, the locations of these sites reflect the Flandrian sea-level change in the same way that the Danish and German underwater Mesolithic sites follow the Littorina Sea transgressions.

Some of the best-known waterlogged (and dryland) Mesolithic sites in Britain are situated rather inland from the present-day coast. However, the relationship with the sea played a crucial role in the Mesolithic people's everyday lives. One of the best areas to study the interface between coastal and inland Mesolithic sites is the Severn Estuary, between England and Wales. Here, not only a clear picture of vegetation history emerges (as shown by the submerged forest of Redwick, or the well-studied elm decline recorded in the Caldicot Level), but there is also evidence of human occupation at Goldcliff and Westward Ho!. Comparative analyses are even possible between animal tracks found in the lower Wentlooge and the fauna remains (animal bones) of Goldcliff Mesolithic seasonal (winter) camp (Bell, 1993, 2001; Bell et al., 2000, 2006). One of the most remarkable discoveries at Goldcliff is the identification of Mesolithic (*c.*5600–4800 cal BC) human footprints (Bell, 2007; Scales, 2007).

Although human footprints have previously been found in the Severn Estuary (Magor and Uskmouth), those of Goldcliff, and in particular on sites C (Fig. 2.3), E, and H are of crucial importance, for they can help identify the demography of Mesolithic populations and the way they interacted with the environment. In fact, not only can human tracks offer an extraordinary insight into people's activities and the age composition of the group (e.g. the ratio of adults to children), but, along with animal tracks, they can contribute to improving our understanding of seasonality. Human and animal footprints trapped within banded sediments can provide useful information as to when (e.g. in which season) they were made, hence identifying the various activities (hunting, fishing, and animal husbandry) throughout the year (Bell, 2007).

Inland waterlogged Mesolithic sites in Britain are not very numerous, although one of them, Star Carr (first half of the ninth millennium cal BC), has become the icon of British Mesolithic research. The site located in the Vale of Pickering, Yorkshire was discovered in the 1940s and promptly excavated by Clark between 1949 and 1951 (J. G. D. Clark, 1954). Thanks to its remarkably well-preserved organic material, the site still remains the best source of Mesolithic archaeological evidence in Britain. Artefacts such as a wooden paddle, flints, animal bones (the famous perforated skull and antler of a deer), and antler harpoon points have triggered a number of interpretations of how and when the site was occupied. Initially, Clark thought that it might have been a winter seasonal camp (J. G. D. Clark, 1954), linked to upland and lowland resource use (J. G. D. Clark, 1972). Reassessments (Legge and Rowley-Conwy, 1988; Mellars, 1999; Mellars and Dark, 1998) have established that the site was used in late spring and summer. A remarkable achievement of these later

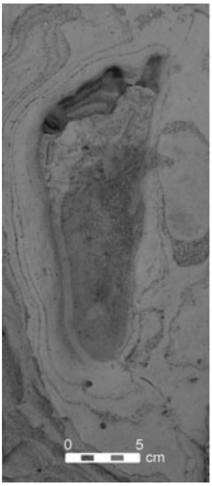


Fig. 2.3. Mesolithic human footprint-track of Goldcliff—person 13, site C (*Photograph*: courtesy of Martin Bell, University of Reading)

interpretations was the identification of repeated burning of the lakeside reed-belts, subsequently interpreted as a method by which hunter-gathers increased the biological productivity of the wetlands, thus attracting more game (Mellars and Dark, 1998). Part of the Star Carr archaeological evidence for which the site has become renowned is the large wooden platform interpreted as a landing place on the edge of the lake. Interestingly enough, it was not until the mid 1990s that John Coles noticed that part of the large amount of wood that made up the platform was cut by beavers and, later on, opportunistically collected by the Star Carr Mesolithic people to construct the platform (Coles, 2003; Coles and Coles, 1996).

Star Carr is not the only Mesolithic wooden platform on the British Isles: a few more have been found in other places. Of particular significance is that of Eskmeals (Bonsall et al., 1989) in Williamson's Moss in the English Lake District (Cumbria). The site stresses the importance of a thorough consideration of these platforms in terms of origin and function. In fact, after being initially regarded as manufactured, a subsequent reinterpretation considered Eskmeals to be the product of naturally decayed woodland (Clare et al., 2001: 103). One Mesolithic wooden platform with unquestionable human origin is that of Kinale II, Lough Kinale, Co. Longford, Ireland. The site, excavated between 2003 and 2005, had been occupied several times between 5500 cal BC and 4000 cal BC. In addition to lithics, Kinale II offers an unprecedented (in Irish Mesolithic) assemblage of worked wood and artefacts, which help to shed light on the people–wetlands interaction (Fredengren, 2002, 2004, 2007). Further evidence of the Mesolithic people's interaction with other lacustrine areas in Ireland has also been found on Lough Boora, Co. Offaly, Lough Derravaragh, Co. Westmeath, Moynagh Lough, Co. Meath, and Lough Allen, Co. Leitrim, although none of these sites have yielded remains of habitations (O'Sullivan, 1998).

Inland waterlogged Mesolithic sites are more common on Europe's mainland. With a few exceptions in the central part of the continent, for instance Lake Feder (Federsee) in Germany (Schlichtherle and Strobel, 1999) and in the Wauwilermoos (former Lake Wauwil) Switzerland (Speck, 1990*b*), the vast majority are located in more northerly latitudes. Two of the best-known waterlogged Mesolithic sites are Friesack, Germany (Gramsch, 1992) and Noyen-sur-Seine, France (Mordant and Mordant, 1992). Friesack, located some 60 km north-west of Berlin, was discovered in the early 1970s and excavated between 1977 and 1989. The two sites (4 and 27) yielded remarkable artefacts (see Ch. 4), and evidence of a series of occupation episodes spanning 9700 to 6600 BP (Gramsch, 1991, 1992, 2000). Noyen-sur-Seine was a riverine summer fishing camp located on the banks of the River Seine (about 100 km upstream from Paris), occupied from 8000 to 6500 BP. A variety of basketry artefacts along with six fish-traps, a possible fish weir, and a dugout (one of the oldest in Europe, see Ch. 4) are part of the archaeological assemblage found in

the lower strata. In the upper layers, fish-traps seem to have been replaced by fish-hooks, showing a change of food procurement techniques from the earlier occupations (Coles and Coles, 1996; Mordant and Mordant, 1992).

As pointed out earlier, traces of Mesolithic wetland occupation are more evident at northern latitudes, and from the Netherlands to Denmark and Sweden, waterlogged sites are not uncommon, retaining remarkable evidence of a Mesolithic way of life, which is much more complex and developed than previously thought. In the Netherlands, for instance, such sites found in the central Bourtanger Moor show a strategic choice of elevated sand dunes near loamy depressions, which provided wet biotopes with attractive flora and fauna (Gronendijk, 2003). At the same time, the Holmegårds Bog in south Zealand (Denmark) shows clear change in settlement patterns throughout the entire Mesolithic, from small and clustered sites in the first phase of the Maglemose Culture (8750–7900 cal BC), to larger settlements with an intensification in the exploitation of the bog during the next three phases (7900–6400 cal BC). This phenomenon is also noticed in other bogs of Zealand, northern Germany, and Scania (Sweden). The Holmegårds Bog was never permanently settled; large settlements around its edge were probably winter camps, whereas those on the peat banks might have been the sites of social gathering of inland populations (Schilling, 2003). Similar examples of seasonal group mobility are found in the Åmose area, where $\delta^{13}C$ analyses of human and dog bones have proved contact and mobility between inland and coastal communities (Fischer, 2003: 406).

Well-preserved Mesolithic sites can also be used to identify both environmental and cultural change; and some of the best-studied ones are found in the Swedish inlands. For instance, the strategic location within the wetlands (usually resulting in a combination of lakes and flowing water surrounded by gentle hills) of three sites (Högby, Storlyckan, and Mörby) near Mjölby in the Östergötland region have not only shed light on wetland formation, as the Yoldia Sea retreated, but also helped to identify important aspects of landscape colonization (M. Larsson, 2003, 2007) (see also Ch. 3). It is interesting to notice that the majority of bog sites in Sweden are from the Early Mesolithic. Those sites (mainly temporary/seasonal camps) were located at the edge of lakes rich in flora and fauna, which were in the process of being filled by peat growth. Once this process was complete (Late Mesolithic) the resultant ecosystem was no longer attractive to hunter-gatherer Mesolithic groups, and they were forced to relocate (L. Larsson, 1998, 2001; M. Larsson, 1998). Some examples of Early Mesolithic bog occupations are the sites on Lake Hornborgarsjön, the Montala settlement (Lake Vättern) (Carlsson, 2008), Tågerup (Karsten and Knarrström, 2003), and Ageröds Mosse, where one of the sites (Ageröd V) dates also to a later phase of the Mesolithic (L. Larsson, 2001: 161).

Inland sites are not only bog occupations, but they could also be the result of isostatic uplifting, as it is the case of the well-studied site of Huseby Klev

(island of Orust). The site was originally a coastal settlement, which was flooded by rising sea levels, sealed by clays, and subsequently uplifted by isostatic processes (Nordqvist, 1995).

Contrary to the western Baltic Sea land bridge, the southern shores (e.g. the Polish coast of Pomerania) were scarcely populated during the Mesolithic (Bagniewski, 1998). Most of the wetland sites were located inland but, even there the number is fairly limited. As is the case for various other regions in northern Europe, also in Pomerania, Mesolithic settlements are mostly located within environments suitable for aquatic fauna and flora exploitation. Another area particularly interesting for the study of early human occupation in wet environments is the Masurian Lake District, and one of the best-researched sites is the Dudka settlement. The site, located on a flat island in a former lake now overgrown by peat, was a seasonal fish camp, periodically occupied from the Late Palaeolithic to the Neolithic (Gumiński and Michniewicz, 2003: 119). Because of its complete stratigraphy, complemented by a well-preserved archaeological assemblage, Dudka (along with other Polish Mesolithic sites), has played a crucial role in the understanding of the Mesolithic-Neolithic transition (see below).

On the eastern coast of the Baltic Sea (and inland too), significant wetland occupations started to appear in the Neolithic (see below). There are, however, Mesolithic sites (especially in the north-east) that are crucial for gaining a better understanding of first human colonization of the post-LGM (Last Glacial Maximum) period. Some of these sites (Võhma I, Saaremaa Island; Kõpu, Hiiumaa Island; and Ruhnu, Ruhnu Island) (Kriiska, 2003) are located on present-day Estonian islands formed as the Baltic Ice Lake was first linked to the North Sea, causing the water level to drop several metres (see above). Mainland settlements were also largely located near the coast, on the edges of water basins, river inlets, and estuaries. The best known and probably the oldest in Estonia is Pulli (*c.*9000–7200 cal BC) (Veski et al., 2005), followed by the site of Sindi-Lodja I, which is 1500 years younger. Another important area for Mesolithic wetland sites is the left bank of the Kunda River. The eponymous Mesolithic site that gives its name to the archaeological period (Kunda Culture) was located on an island (Lammasmägi) in a lake, probably occupied seasonally. The area subsequently paludified, covering and preserving the rich archaeological assemblage. A few more wetland Mesolithic sites, namely Villa 1, Akali (previous name Konsa), and Kääpa (Piezonka, 2008) are to be found in the south-eastern part of the country.

An area in the Baltic Sea crucial for the understanding of the first colonization of the far north-eastern part of Europe is southern Finland and the Karelian Isthmus, between the Baltic and the Ladoga Lake (Russia). Finnish archaeologists always wondered why there were no Preboreal settlements in Finland, while their presence in the neighbouring countries was certain. It was thought that one of the plausible reasons could have been the transgressive

Ancylus Lake, which might have destroyed them. The discovery of the Ristola site fully confirmed this possibility. Not only was the site covered with Ancylus Lake sediments (proving an *ante quem* date to the Ancylus transgression), but it also yielded material culture comparable to that of Pulli, other Preboreal settlements of the Baltic Sea regions, and even to the Butovo Culture in the Upper Volga area (Russia) (Jussila and Matiskainen, 2003: 664). More supporting evidence comes from two sites, both located in the Karelian Isthmus, namely Saarenoja 2 (Finland) and Antrea (Russia).

Unmistakable traces of wetland Mesolithic settlements are also found in the north-western Russian territory, and more precisely in the Upper Volga River region. Some of the best-studied wetland settlements, which have yielded extraordinarily well-preserved archaeological assemblages ranging from bone and antler artefacts to finely worked wooden objects, are those of Butovo (eponymous site that gives the name to the Butovo Culture), dating from *c.*9310 ±110 BP, the site of Stanovoje 4 (the earliest site of the Butovo Cultural group, *c.*10300 ±70 BP) in the Podozerskoye peat bog, Ivanovskoje 7 (*c.*9650 ±110 BP), Ozerki 5, 16, and 17 (*c.*7410 ±90 BP; *c.*8870 ±40 BP; and *c.*8840 ±50 BP), Okajomovo 5 (lower layer *c.*7910 ±80 BP), Nushpoli 11 (*c.*7310 ±40 BP) (Zhilin, 2007: 66–74, 1999, 2003), Sakhtysh 14 (10030 ±60 to 7200 ±40 BP) (Zaretskaya et al., 2005), and Zamostje 2 (*c.*7380 ±60 BP) (Chaix, 2003; Lozovski and Ramseyer, 1995; Lozovski and Ramseyer, 1998). A few of these sites had more than one occupation, not only in the Mesolithic, but also during the Neolithic and even in the Bronze Age (see below).

Remaining in Russia, a remarkable selection of outstandingly preserved wooden artefacts has been found at Vis I (*c.*8350–7000 BP) near Lake Sindor in the Vichegda basin (Burov, 1989, 1998). Amongst the various objects, of major importance are fragments of sledge runners, bark containers, bows, a variety of fibrous binding materials, and fishing nets (see Ch. 4).

Mesolithic–Neolithic Transition

Thanks to their rich material culture assemblages, wetland sites offer further help in deciphering the transition to the Neolithic, whether 'transition' is understood to mean the introduction of agriculture (as is the case in central and western Europe), or the first adoption of pottery (north-eastern Europe and Russia) (Price, 2003; Timofeev, 1998; Zvelebil and Lillie, 2000). This division can be confusing sometimes, as archaeological periodizations are not the same everywhere. See for instance the case of southern Finland, where the introduction of pottery occurred at *c.*6000 BP, whereas the boundary of agricultural activity is set to *c.*4000 BP (Vuorela, 1998: 175). Or the case of the Upper Volga region (Russia), where at *c.*7000 BP, one can speak of the Neolithic already, but agriculture does not begin until much later, and in some areas not even until the Bronze Age.

The late or delayed start of agriculture in some areas of Europe was due to a number of factors, resulted from a combination of cultural and environmental variables (see also Ch. 3). In most cases, cultural groups located in the interface areas between hunter-gatherers and agriculturalists adopted opportunistic economies tailored to suit their needs. This constant shifting in both economic directions (hunter-gatherer and agricultural) is not easy to spot in solely lithic archaeological assemblages; hence the importance of waterlogged sites with well-preserved perishable organic material, which would be lost in normal dry conditions. Areas most suitable to the study of the Mesolithic-Neolithic transition (in particular the adoption of agriculture) are, once again, located at northern latitudes, and some of the best examples are found in southern Scandinavia (namely Denmark and Sweden), northern Europe (northern Germany and Poland), and the north-eastern Baltic Sea region and north-western Russia (the latter more concerning the introduction of pottery). A crucial wetland site, which has shed significant light on the shift to agriculture, is that of Wangels LA 505 (Grube-Wessek valley, northern Germany). Here the transition to the Funnel Beaker Culture has been dated to 4150 cal BC (date obtained from encrusted food on pottery). Interestingly enough, domesticated animals (sheep, goats) seem to have appeared here well before the arrival of the Funnel Beaker Culture, contradicting the evidence from Denmark and Scania, where pottery and domesticated animals came as a package around 3950 cal BC (Hartz and Lübke, 2004; Zhilin, 2007). Of major importance are also the wetland sites of Hardinxveld in the Rhine/Meuse Delta, the Netherlands. The significance of the Hardinxveld sites lies in the fact that they are located outside the rich wetland Mesolithic zone of Denmark-Schleswig, hence offering new information on non-lithic material, subsistence elements, settlement systems, and first contact to agrarian communities in north-western continental Europe (Louwe Kooijmans, 1998, 1999, 2003, 2006). In addition to expected similarities with the dominant Scandinavian data, artefact typology shows social, economic, and ideological differences, pointing out a different (and earlier) trajectory of agropastoral transformations. The concept of agricultural frontier introduced by Zvelebil (1998) to study the transition to farming in the Baltic Sea regions is applied to the Polish Lowlands of Kuiavia, to show the interface zone between hunter-gatherers and Linear Pottery (LBK) communities. The Chojnice-Piénki and Janislawice hunter-gatherer groups developed two distinct frontiers of contact: the stationary frontier (Dennell, 1985) adopted by the former group, and the mobile frontier (Zvelebil, 1998) used by the latter. The differences between these two cultural group zones were linked to their diverse settlement network (Domańska, 2003: 591).

The majority of sites in the Polish Lowlands, which are chronologically placed in the Mesolithic-Neolithic transitional period, show evidence of only the first introduction of pottery, and some of the best-studied sites are Sośnia

and Woźnia Wieś in the eastern Lowlands (Sulgostowska, 1998), and Chwalim and Chobienice in the western Lowlands (Kobusiewicz and Kabaciński, 1998). The introduction of agriculture in the Lowlands occurred only later. An example of conservative economy comes from the well-known peatbog of Dudka, where a significant change in subsistence strategies can be noticed only in the Middle Zedmar Culture stage (*c*.2900 BC) (Gumiński, 1998: 103; Gumiński and Michniewicz, 2003). In the Drawsko region of Pomerania and in the Kashubian Lake District, Mesolithic economies lasted until the Early Bronze Age (Bagniewski, 1998: 118), and it is believed that the particular environmental conditions and terrain morphology are to blame (Jankowska, 1998: 121).

Controversial evidence of animal husbandry comes from Deby 29. It is argued (Domańska, 1998; Lasota-Moskalewska, 1998) that its inhabitants had knowledge of animal husbandry, which had links to the northern parts of the Black Sea. The major issue remains chronology; in fact, radiocarbon dates place these early processes of Neolithization at Deby 29 almost 2000 years earlier than previously believed by the vast majority of scholars (Niesiołowska-Śreniowska, 1998).

The beginning of the Neolithic in the further eastern regions of the Baltic Sea is more linked to the introduction of pottery, and also here, as in southern Scandinavia and Finland (see above), the adoption of agriculture occurred at a later date. The two predominant early ceramic cultures of the Baltic Sea's eastern regions are the Narva (Estonia, Latvia, and parts of Lithuania) and Neman (north-western Poland, north-western Belarus, and south-eastern Lithuania). In order to understand their diffusion, it is crucial to identify similarities and discrepancies that derive from preceding local industries, such as the Late Mesolithic Kunda and Narva cultures. Interestingly enough though, some of the pottery assemblages of the eastern Baltic Sea regions are also comparable with Early Neolithic sites of the Russian forest zone, and it is even possible that the introduction of pottery in this area coincides with the beginning of agriculture in the Loess plains of central Europe (Timofeev, 1998: 227).

Neolithic

As briefly mentioned above, the beginning of the Neolithic can be determined in two ways: from the introduction of pottery, or from the adoption of agriculture. This seemingly confusing differentiation is nevertheless useful to monitor and understand the complex transitional period to farming. In fact, although the introduction of pottery is sometimes seen as an influence of farming societies, it does not reflect an immediate adoption of agriculture. The transition depends upon a number of variables, linked to the delicate balance

between environmental, cultural, and ideological factors. In some cases this balance is never established and, as a result, the transition never occurs.

Typical examples of sites where, despite the early introduction of pottery and the transition to agriculture took place quite late, can be found in western Russia, the eastern region of the Baltic Sea, and northern Scandinavia (Dolukhanov, 1992; Dolukhanov and Mazurkevich, 2000; Zhilin, 2007). Here, territories already occupied in the Mesolithic continued to be settled throughout the Neolithic, with only small changes in subsistence strategies. An interesting area with remarkable evidence of people–wetlands interaction, subsistence strategy change, and contact in the Neolithic is the Upper West Dvina (western Russia) and Belarus. The sites of Serteya 2, Dubokrai, and Usvyaty 4 (first half of the third millennium cal BC) for instance, contain coprolites of wild pigs kept in captivity and fed with fish. It is even possible that some cereals were also cultivated in small areas adjacent to the lakes (Dolukhanov, 2004; Kuzmina, 2003; Mazurkevich and Dolbunova, 2011). Pottery typology also shows contact with some Globular Amphora, Funnel Beaker, and Corded Ware neighbouring groups (Szmyt, 1996), although the influence of these groups on local populations was not very marked (see also Ch. 3).

Present-day northern Belarus, and in particular the Paazerje Lake region is fairly rich in Neolithic wetland occupations. Three of the best-studied sites of this area are Zacennie (*c.*6400–5400 BP to Early Neolithic Narva Culture), located on the left bank of the Can River, and the sites within the Kryvina peatbog: Asaviec 2 (*c.*4400–3350 BP) and Asaviec 7 (*c.*3800–3250 BP). The amount of archaeological material recovered from the latter two sites is impressive; 26,000 fragments of pottery in Asaviec 7, and about 50,000 in Asaviec 2. The assemblages show contact with neighbouring groups such as the Narva, Usviaty, and even the Middle Dnieper Culture. There are bone and antler artefacts in large quantities in both sites (Charniauski, 2006, 2007). More wetland settlements are located in the Polissya region, in southern Belarus. Here some of the best-researched sites are: Kuzmichy 1 (Lake Kuzmitskaye), dating from *c.*4700 to 3800 BP (Kryvaltsevich et al., 2008) and Aziarnoye 2B (*c.*late fourth to early third millennium cal BC) (Kryvaltsevich, 1996).

Shifting attention westwards to the Baltic Sea, and more precisely to Estonia, it is noticeable that the majority of Neolithic wetland settlements are located in the eastern and south-eastern parts of the country. A few well-known sites here were multi-occupation sites, starting from the Mesolithic (see for instance Kääpa, Akali, and Villa 1). There are, however, settlements with occupations exclusively from the Neolithic. For instance one of these is Tamula 1, which spans two cultural units, from the Late Combed Ware to the Corded Ware (*c.*4600–2000 cal BC). The site is remarkable, for the settlement itself also includes a cemetery with 25 graves. The extraordinarily well-preserved archaeological remains have allowed light to be shed on previously

unknown local funerary practices, such as the wrapping of the dead in birch bark (Jaanits, 1984; Kriiska et al., 2007) (see also Ch. 4). Remains of pile-dwellings (*c*.3300–3200 cal BC) have also been found on Lake Valgjärv (also called Lake Koorküla-Valgjärv). The settlement was located on a small peninsula, but it is still unclear whether the houses stood in the water (on a narrow submerged morainic shoal), or in its close proximity (Selirand, 1986; Virtanen, 2006).

Evidence of riverine sites have been found on the bottom of the Pärnu River (south-western Estonia). Interestingly enough, the settlements were not located in the river, but on its banks; the artefacts were, at a certain stage, dragged into the water by the dynamic activity of the river itself during a period of climatic instability (Kriiska et al., 2002).

Latvia and Lithuania also hold evidence of Neolithic wetland occupation. In Latvia, for instance, various settlements have been found on Lake Lubana (Loze, 2001), and on the famous coastal peatbog of Sarnate. In Lithuania, Neolithic wetland sites have been discovered on Kretuonas Lake (Girininkas, 1980), Lake Biržulis (Butrimas, 1998), and amongst the wetlands of Šventoji, where more than 40 sites have been recorded. Three of these sites, namely Šventoji 3B, 23, and 6, are particularly important for they retain one of the first evidences of agriculture activity (*c*.3000–2600 cal BC) on the eastern Baltic Sea coast (Rimantienė 1992*a*, 1998: 213).

The multi-phase occupation of Dudka (Poland) is an excellent example of people's adaptation to the wetlands and surroundings areas. Climate change combined with the advancing process of Neolithization shaped particular adaptation patterns from the Mesolithic to the Neolithic. Forest and game management show the effects of the introduction of pottery and animal husbandry, resulting in the disappearance of long-standing food procurement strategies such as hazelnut cultivation (Gumiński and Michniewicz, 2003).

Climate change played an important role also in southern Scandinavia (particularly in Sweden), not only in terms of sea level fluctuations but also landscape shaping inland. Here lakes and other minor water basins underwent a fairly rapid process of infilling throughout the Mesolithic. As a result, a number of wetlands had already dried out and become covered with forest by the beginning of the Neolithic (*c*.4000 cal BC) (L. Larsson, 2007*a*). Although interaction with the wetlands remained germane, settlements were then placed on more elevated ground (dunes or small land protuberances), and the functional use of the wetlands diminished. In Denmark, for instance, a major change occurred in the third millennium cal BC, and in particular during the transition from the Single Grave Culture (SGC) to the Late Neolithic (LN) period, when the SGC groups expanded onto more fertile soil in eastern Jutland, increasing the overall economic importance of cereals (Klassen, 2008). The settlements of the LN period were mainly small single farmsteads situated between fields and meadows (Siemen, 2008). Also during the Bell Beaker period, settlements seem to be located near more fertile soils, away

from swampy areas. A typical example of this period is the site of Bejsebakken (Sarauw, 2008).

In the marshes along the estuary of the Rhine and Mause, Neolithic settlements, although still scarce, seem to have been linked to and more integrated within the wetlands. Hunting, fowling, and fishing were still important activities at Swifterbant, Bergschenhoek, and Hazeldonk (Early/Middle Neolithic), as much as they were at Schipluiden in the Middle Neolithic (Louwe Kooijmans and Jongste, 2006), or at Hekelingen III and Vlaardingen in the Late Neolithic (Louwe Kooijmans, 1987).

Despite the tendency of living in drier areas, Neolithic people of northern Europe and Scandinavia kept a close contact with the wetlands. This is not only proved by the numerous offerings and depositions in Sweden and Denmark, but also by the large number of wooden trackways built in the peatbogs of northern Germany and in the Netherlands. People in Sweden, for instance, did not only use wetland environments as deposition places, but also lived there seasonally, as is demonstrated by the enigmatic gathering place of Alvastra (*c.*3100 cal BC) (Göransson, 1995; L. Larsson, 1998, 2001). Wetland deposition also took place in the Netherlands and northern Germany, where swampy areas and peatbogs were penetrated and traversed over vast distances. Here, a number of wooden trackways were constructed from the Neolithic (possibly even earlier) to the Roman period and beyond, and it is indeed in northern Germany (Campemoor) that the oldest (4780 cal BC) trackway in the world, namely Pr 31 (also known as XXXI (Pr)), has been discovered (Bauerochse, 2003; Bauerochse and Metzler, 2003) (see also Ch. 4).

People–wetlands interaction in the Neolithic was also fairly active in the British Isles. As in other parts of northern Europe though, the majority of settlements were located on elevated ground, and the exploitation of the wetlands varied from place to place. For instance, wetland resources were complementary rather than essential for the Humber wetlands people (Van de Noort, 2004*a*), as much as they were in the Severn Estuary, where mainly minor pastoralist activities took place (Bell, 2001). The Fenland in eastern England was exploited in a similar way; settlements were built on higher ground and the fens were used seasonally for animal grazing. Cultivation, on the other hand, was more concentrated where the terrain was not too wet (Coles and Hall, 1998; Pryor, 2005). The Fenland has always been a place where sacred and profane mixed together in harmony, and one of the typical examples in the Neolithic is Etton (*c.*3000 cal BC) (Pryor, 1998). Further evidence of an active contact with the wetlands in Neolithic England is also found in the Somerset Levels, where marshes and peatbogs were extensively criss-crossed by a myriad of wooden trackways. The best known is of course the Sweet Track, which is also the oldest (3806 BC) in Britain, but a number of other trackways (namely Bisgrove, Chilton, Honeygore, Garvin, Jones, Honeygore Complex, Baker, Blakeway, Walton/Rowland, Bell, and Abbot's

Way) dating between 3700 and 2500 cal BC, are also part of the Somerset Level complex (Coles, 1980; Coles and Coles, 1986; Coles and Orme, 1984*b*) (see also Ch. 4).

The situation in Ireland is slightly different. Here there is evidence of more permanent settlements than in Britain, from the Early Neolithic onwards (Cooney, 1997, 2000). Peatland archaeological evidence from the Irish Midlands shows a high number of wetland sites (mainly wooden trackways), in sharp contrast to the striking paucity of dryland settlements (McDermott, 2007: 25). One of the best-studied areas is Mountdillon, Co. Longford near Lough Ree, where, of the around 140 known *toghers* (wooden trackways), about 60 have been thoroughly investigated. Although the majority date from the Bronze Age (see below), there are at least five (Corlea 8, 9, 10, and 11; and Cloonbony), which were constructed in the Neolithic, between 3600 and 2500 cal BC (Raftery, 1996*d*: 284).

According to O'Sullivan (1998), the scarcity of Neolithic sites around the Irish loughs could be the result of a 'biased' orientation of Irish archaeological research, which has tended to ignore lake-shore occupation. There are lakes, such as Lough Enagh (Northern Ireland), Lough Gara, and Lough Gur, for instance, where possible Neolithic archaeological assemblages have not been properly considered, and therefore chronologically misinterpreted (O'Sullivan, 1998: 61–9). A similar situation could be seen in Scotland, where, apart from a few known lacustrine occupations—one of them being Eilian Domhnuill, Loch Olabhat (Ashmore, 1996)—the majority of lake-settlements (mostly known as crannogs, see Ch. 4) are from the Iron Age (Henderson, 1998*a*, 2007*a*; Henderson et al., 2003).

An area of Europe particularly rich in Neolithic wetland settlements is the Circum-Alpine region including western France, Switzerland, southern Germany, Austria, Slovenia, and northern Italy. This is where the so-called lake-dwelling phenomenon of central Europe started towards the end of the fifth millennium cal BC (see Ch. 4). Although believed to have had its origins in the Mediterranean region (Schlichtherle, 1997*b*), it is in the northern parts of the Alps that the lake-dwelling tradition reached its apex of development. Pioneering key sites, such as Egolzwil 3 (Wauwiler Moor) (E. Vogt, 1951) and Petit Cortaillod (Lake Neuchâtel) in Switzerland (Hafner and Suter, 2000; Stöckli et al., 1995), and Hornstaad-Hörnle 1A (Lake Constance) (Dieckmann et al., 2006) and Aichbühl (Lake Feder) (Schlichtherle, 2002) in Germany, have set the pace for one of the most proliferous lake-settlement traditions in prehistoric Europe. A vast variety of Neolithic lake-dwellings, spanning from the forty-third to the twenty-sixth century cal BC, have helped shed light on the complex Neolithization process of the Alpine region and surroundings. While multi-occupation sites such as, for example, ZH-Mozartstrasse, ZH-KanSan (Lake Zurich), Twann (Lake Biel) in Switzerland, Chalain (Lake Chalain) in France, and Sipplingen-Osthafen (Lake Constance) in Germany have helped

archaeologists study patterns of occupation linked to cultural, economic, and environmental changes through time and space, single-phase perfectly preserved settlements (known as Pompeii-type), such as the of Arbon-Bleiche 3 (Lake Constance, Switzerland) (Jacomet et al., 2004; Leuzinger, 2000), have identified socio-economic spatial division at the settlement and household level (Doppler et al., 2011; Ebersbach, 2010*a*; Jacomet and Brombacher, 2005*b*). Furthermore, high-resolution dendrochronological dating of settlements in a circumscribed micro-environment (e.g. Lake Feder, Germany) has even been able to monitor settlement dynamics within a given territory occupied by one or more settlement units (*Siedlungskammer*) (Billamboz, 2005; Bleicher, 2009; Zimmermann et al., 2004). Significant Neolithic lacustrine and marshland settlements are also found on the southern slopes of the Alps, mainly in northern Italy and Slovenia. Amongst the best-studied are the late sixth millennium cal BC site of Isolino Virginia (Lake Varese) and the Neolithic occupation of Fiavé (former Lake Carera) Italy, and the various settlements of the Ljubljana Marsh, starting from Resnikov Prekop in the second quarter of the fifth millennium cal BC (Velušček, 2004, 2009). The lake-dwelling tradition in the Circum-Alpine region also continues throughout the Bronze Age (see below), coming 'suddenly' to an end in the seventh century cal BC, just before the Iron Age.

Neolithic lakeside dwellings outside the Circum-Alpine region (including Lake Feder) are not very numerous, but nevertheless crucial for a better understanding of the lake-dwelling phenomenon as a whole. In the Mediterranean region, for instance, the oldest is Sovjan (*c.*7000 cal BC) former Lake Maliq in Albania (Touchais and Fouache, 2007; Touchais et al., 2005), followed by Dispilio (*c.*5300–3500 cal BC) on Lake Kastoria, Greece (Hourmouziades, 1996), La Marmotta (*c.*5500–5200 cal BC) on Lake Bracciano, Italy (Fugazzola Delpino, 1995; Fugazzola Delpino and Pessina, 1999), and La Draga (*c.*5400–5000 cal BC) on Lake Banyoles, Spain (Bosch et al., 2000, 2006). These sites are believed to be the precursors, and therefore the possible origins of the lake-dwelling tradition mentioned above (see Fig. 2.4).

In central-northern Europe, two more significant Neolithic lakeside settlements are those of Hunte 1 (*c.*3250–2550 cal BC) (Kossian, 2003, 2007) and Hüde 1 (*c.*4200–2700 cal BC) (Deichmüller, 1975; Kampffmeyer, 1983), both located on Lake Dümmer, northern Germany.

Needless to say there is a large number of Neolithic settlements, which, although not considered to be wetland (or wet) sites, are nevertheless of crucial importance for understanding people–wetlands interaction in the Neolithic (see Ch. 8). Typical examples are river-bank and dryland settlements encompassed into large water basins such as Lake Balaton in Hungary (Fábián and Serlegi, 2009).

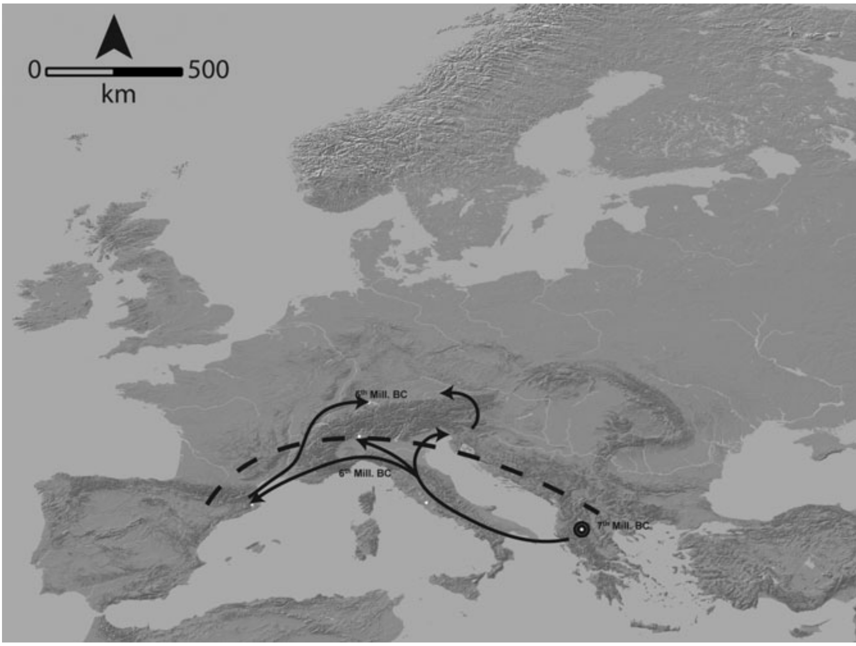


Fig. 2.4. Possible origins and expansion of the Circum-Alpine region lake-dwelling tradition. (*Graphic*: José Granado. Base map created using STRM data and ArcWorld River and Lake Overlay.)

Bronze Age

The transition from the Neolithic to the Bronze Age in the European wetlands did not encompass drastic changes. By the Early Bronze Age, with the exception of only some areas of northern Scandinavia, eastern Baltic Sea, and north-western Russia, the majority of Europe had already adopted agriculture, and in some places (e.g. the Circum-Alpine region), metalworking had already become an integrated part of the wetland people's economy. This is not to say that people–wetlands interaction in the Bronze Age was homogenously similar throughout the continent. Contact with the wetlands was in some cases linked to subsistence and economy, and in some others to sacred activities, such as rituals and/or offerings. In Sweden, for instance, the Neolithic tradition of offerings and depositions in inland peatbogs continued throughout the Bronze Age, as is shown by the Fröslunda Bog (near Lake Vättern), where a collection of bronze shields (sixteen shields of the Herzsprung type—*c.*950 cal BC) was located in the mid 1980s (Hagberg, 1988).

Bronze Age peatbogs of northern Europe were not only penetrated marginally for sacred reasons, but they were also crossed extensively for a number of other purposes (e.g. communication, trade, social interaction, etc). It is certain

though that whatever the motivation might have been, the wetlands were never considered to be an insurmountable obstacle. This is clearly shown by the large number of wooden trackways found in northern Germany (see for instance the fine corduroy road of Ockenhausen/Oltmannsfehn in the Lengener Moor) (Fansa and Schneider, 1993), those in Ireland (the various trackways of Corlea and Derryoghil) (Raftery, 1996*d*), and the less numerous, but by no means less relevant ones in England (the trackways of Eclipse, Meare Heath, Tinney, and Westhay in the Somerset Levels, and the post alignment of Flag Fen in the Fenlands) (Coles and Coles, 1986; Coles and Orme, 1980; Pryor, 2001, 2005) (see also Ch. 4).

Bronze Age wetlands at northern latitudes were not used just for offerings or viewed merely as obstacles to be crossed. In Denmark, for instance, there were permanent settlements whose economies were perfectly integrated with the surrounding wetland landscape. One of the best examples is the Bjerre area in northern Jutland, exploited by a number of small farm units (no more than one or two at a time) for about 1000 years (between 1500 and 500 cal BC) (Bech, 1997: 5). Thanks to the excellent preservation, the numerous sites (nineteen) found in the area have yielded remarkable evidence of Bronze Age farming life, house layouts, economy, and subsistence. Thanks to soil and micro-fossil analyses of plant remains, not only have archaeologists identified ancient field systems (e.g. the ard furrows of Bjerre 4), but they have also been able to prove that peat was used for fuel (the earliest evidence of this practice in Denmark, see Bech, 1993, 1997). From the rich Bjerre archaeological assemblage it has furthermore been possible to trace similarities in cross-cultural animal husbandry (parallel stock frequencies with Dutch material from West-Friesland), spot the increase in amber collection in the Bronze Age (for possible long-distance trade) (Earle, 2002), and re-examine the chieftain status issue in relation to house size and bronze swords (Bech, 2003: 57; Fokkens, 1999; Kristiansen, 1984, 1998).

On the British Isles, Bronze Age permanent/seasonal residential units within the wetlands and people's exploitation of wet environments varied considerably from place to place. While sites such as St James and Newark Road show permanent occupation and use of extensive field systems on the southern edges of the Fenland (Coles and Hall, 1998; Pryor, 2005), the Humber wetland farming activities were more focused on limited stockbreeding. A full development of wetland-edge field systems was, according to Van de Noort (2004*a*: 54), precluded by the continuous expansion of wet environment, making grazing grounds more available in the Humber Estuary than in the river floodplains. Similar environments are also found in other estuary areas. One of the best examples is the Severn Estuary (western England and Wales), where seasonal occupation linked to wetland grazing grounds has been discovered at Chapel Tump 2, Rumney, Cold Harbour Pill, and Redwick (Bell, 1999).

A rather different situation is found in Ireland, where evidence of intense Bronze Age (in particular Middle and Late Bronze Age—*c*.1700–700 cal BC) people–wetlands interaction is not only shown by the plentiful *toghers* built within peatbogs and marshlands, but also by the number of seasonal and/or permanent settlements found around the loughs. Although generally called 'crannogs' and regarded as small residential units, these wetland occupations had different functions. Some of them (e.g. Cullyhanna Lough, Lough Eskragh site A (Northern Ireland) and Clonfinlough) (Mallory and Mcneill, 1991; B. B. Williams, 1978) might have been agricultural farmsteads, while the rich archaeological assemblage of Rathtinau (Crannog 61) on Lough Gara, Ballinderry 2, and Moynagh Lough might suggest high-status residences, or special gathering places (J. Bradley, 1991; O'Sullivan, 1998; Raftery, 1994). We know for sure that the economy of these Bronze Age sites was not essentially based on agriculture. Clay moulds for casting bronze objects and crucibles found at Lough Eskragh, Rathtinau, and Killymoon, for instance, argue for fairly large-scale metalwork production, along with a developed trade network. There is also the possibility that some sites had multiple functions. The presence of weaponry at Ballinderry 2, Killymoon, and Moynagh Lough, hoards at Ballinderry 2 and Knocknalappa, and humans skulls from Ballinderry 2 and Moynagh Lough might suggest either defence and/or cult places (O'Sullivan, 1998). There are also recurrent features that make the interpretation of these wetland sites even more arduous. A typical example is the still poorly understood *fulachta fiadh*, often associated with wooden troughs or fire-baskets (see for example the one at Rathtinau (Crannog 61)), which are believed to be cooking places or even saunas (O'Sullivan, 1998: 71).

Bronze Age lacustrine settlements known as crannogs are also found in Scotland, although here the crannog tradition did not fully develop until the Iron Age (Henderson, 1998*a*, 2007) (see below).

Another area of Europe where Bronze Age lakeside settlements were particularly numerous is the Circum-Alpine region. The lake-dwelling phenomenon started in the Neolithic and continued throughout the Bronze Age, coming to a sudden end in the northern Alpine region just before the beginning of the Iron Age (Menotti, 2004*b*; Schlichtherle, 1997*b*). The chronology was slightly different on the southern slopes of the Alps. Here, not only did the lake-dwellings disappear earlier (thirteenth–twelfth century cal BC), but there was also the development of a distinct synchronic wetland site tradition, known as the *terramare*, during the Late Bronze Age (see Ch. 4).

A totally different picture is seen in the eastern regions of the Baltic Sea, where, although sporadic wetland sites were already present in earlier times (see above), significant lacustrine settlements did not appear until the very end of the Bronze Age and beginning of the Iron Age (Gackowski, 2000; Menotti et al., 2005: 383; Pydyn, 2007: 323). On the other hand, if we go further east (e.g. Belarus, north-western Russia, and Upper Volga region), we notice for

instance that major wetland sites such as Kuzmichy 1, Aziarnoye 2B, and Kamen 8 ceased to be settled right at the beginning of the Bronze Age, after a long Neolithic occupation. Contact with the wetlands continues of course, although slightly drier environments were preferred.

At southern latitudes, and more precisely around the Mediterranean, Bronze Age wetland sites were, as in the Neolithic, not very numerous. There were areas nevertheless, such as the lacustrine region on the border between Albania and Macedonia, where occupation particularly thrived. Pile-dwellings are found on the Macedonian shores (a few also on the Albanian shores) of Lake Ohrid (Kuzman, 2009), and at Sovjan (formerly Lake Maliq, Albania), which retains a well-preserved Bronze Age occupation dating to the end of the third millennium cal BC (Lera and Touchais, 2004; Touchais and Fouache, 2007; Touchais et al., 2005).

Finally, although, as pointed out above, northern Italian lacustrine settlements disappear towards the end of the second millennium cal BC, interaction with the wetlands did not cease. This is clearly proved by the wooden structures of a twelfth–eleventh century BC marshland site discovered near Stagno in Tuscany (Giachi et al., 2010), and by the riverine settlement of Poggiomarino on the River Sarno near Pompeii (Albore Livadie et al., 2005; Cicirelli and Albore Livadie, 2008; Menotti, 2004*c*; Pruneti, 2002). The importance of Poggiomarino does not rely only on its crucial chronological setting (transition Bronze Age to Iron Age, sixteenth–seventh century cal BC) (Heussner, 2008), but also on its links to the long-distance transalpine trade, which is crucial for a better understanding of the significant proto-historical cultural changes in the Mediterranean as well as in central Europe.

Iron Age until AD 1

As the subheading implies, this part does not cover the entire European Iron Age, but only the BC period. In fact, in some parts of the continent, the Iron Age continued well into the first millennium AD, reaching, in some cases, the Early Medieval period (see Fig. 2.1). Wetland occupation in Europe during the Iron Age varies considerably from place to place. While in some areas it is registered in a sharp decrease in settlements, in others the numbers increased significantly. In the Circum-Alpine region, for instance, the last evidence of the 3500-year-long lake-dwelling tradition is the settlement of Ürschausen-Horn (*c*.850–635 BC) on Lake Nussbaum, Switzerland (Gollnisch-Moos, 1999). After Ürschhausen-Horn, not a single lakeside settlement is to be found throughout the entire Circum-Alpine region. In the Alpine region's surroundings, Iron Age wetlands were not very popular either. For example, on Lake Feder, which had been fairly well populated throughout the Neolithic and Bronze Ages, the only trace of people–wetland interaction after the last Bronze Age settlement of

Wasserburg-Buchau (*c.*900 BC) (Kimmig, 1992) was the fish weir (but no settlement) of Oggelshausen-Bruckgraben (*c.*620 BC) (Köninger, 2000, 2002). In order to find evidence of Iron Age settlements we have to step outside the Circum-Alpine region, with the closest (in terms of distance) being the Roseninsel site (*c.*392 BC) on Lake Starnberg, southern Germany (Schlitzer, 2008, 2009; W. Schmid et al., 2009). Other Iron Age wetland settlements of central-western Europe and the Mediterranean regions are those of Put Blanc (seventh–fourth century cal BC) and L'Estey du Large (third–first century cal BC) on Lake Sanguinet, France (Maurin, 2006), Poggiomarino, southern Italy (sixteenth–seventh century cal BC) (Albore Livadie et al., 2005; Cicirelli and Albore Livadie, 2008), and the few pile-dwellings of Lake Ohrid, Macedonia (Kuzman, 2009). As we move northwards, wetland Iron Age settlements become more numerous. It is indeed within this period that, for instance, the Scottish crannog tradition was at its apex, with a large number of settlements being built around the various lochs (Crone, 1993; Henderson, 1998*a*) (see also Ch. 4). Surprisingly enough though, Iron Age settlements are very scarce in Ireland, where people seem to have lost their interest in the wetlands during this period. The apparent lack of interaction with the wetlands is not only reflected by the paucity of settlements, but also the aforementioned *toghers* decreased in number considerably (Raftery, 1996*d*). There are, however, areas, such as the site of Edercloon, where the contact with the wetlands is still discernible (C. Moore, 2008).

Despite a general tendency towards a wetter climate, in England people seem to have kept close ties to the wetlands during the Iron Age. Cultural response to climate deterioration was, of course, present, but it was not the same everywhere. For instance, while a hiatus in major construction is noticed in the Somerset Levels during the early part of the Iron Age (*c.*700–400 cal BC), people's contact with the wetlands in the Fenland continued regularly. In fact, a widespread development of Iron Age settlements (e.g. Cat's Water) is noticed around the fen-edge, on 'fen-islands', and onto siltland deposits (Coles and Hall, 1998). Cultural and environmental landscape transformations also occurred in the Humber wetland, where, precisely during this period, the first development of field systems took place in the area (Van de Noort, 2004*a*). Wetland settlements were not particularly numerous, and one of the very few examples is Sutton Common, a mysterious 'marsh fort' with possible ceremonial and high status significance (Parker Pearson and Sydes, 1997).

Seasonal exploitation of estuaries continued throughout the Iron Age, with wooden trackways as well as houses constructed within the interface zone of land and sea. Typical examples are the short trackways, along with the rectangular house structures of Goldcliff located in the Severn Estuary (Bell, 1999; Bell et al., 2000). In England, permanent residential units constructed within wetland environments and preserved in waterlogged conditions are found only in the Somerset Levels, and more precisely at Glastonbury and

Meare (two sites). Glastonbury was occupied from *c.*250 to 50 cal BC, when it was finally abandoned due to an increase in wet conditions that rendered it unsustainable (Coles and Minnitt, 1995). Not far from it lay another settlement, Meare, which was probably established even before Glastonbury, and was occupied only seasonally. There is also the possibility that Glastonbury was set up as an offshoot of the Meare gathering and trading centre (Coles and Coles, 1996).

Similar wetland occupations are found on mainland Europe. One of the best examples is the village of Feddersen Wierde in northern Germany, whose initial occupation was almost synchronic to the last phase of Glastonbury (Haarnagel, 1977; P. Schmid, 2002; Schmid and Schuster, 1999). The layout of the houses, on the other hand, was completely different; instead of round buildings, the houses had a rectangular shape. The settlement continued to be settled throughout the Roman period and beyond (see below).

The Iron Age is definitely the time of fortified settlements (both hilltop and lowland sites) in various parts of Europe, and the wetlands are not exceptions. Examples of protected wetland settlements were already present in the Late Bronze Age, with Wasserburg-Buchau (Lake Feder, southern Germany) being one of the best researched (Kimmig, 1992). This tendency of strongly fortifying the settlements within wetland environments increased in some parts of Europe (e.g. Poland) during the Iron Age, and Biskupin (Niewiarowski et al., 1992; Piotrowski, 1998) is the best representation of such a trend. Iron Age wetland occupation in the eastern Baltic Sea regions is very much localized. While there are areas, such as the Masurian Lakes (north-eastern Poland), where the number of lacustrine settlements increased significantly during this period, in other areas such as Lithuania and Estonia the lake settlements were significantly less numerous than the abundant 'terrestrial' sites (so-called 'hillforts') (Valk, 2008). Two of the best-known Iron Age lacustrine settlements are those of Lake Luokesas (Menotti et al., 2005), and the earliest occupation on Lake Valgjärv in Estonia (Roio, 2007: 28; Virtanen, 2006).

Iron Age wetland exploitation in relation to agricultural activity and/or livestock rearing also varies from place to place and from period to period. Although by this time agriculture had been adopted almost everywhere, in some areas of northern Scandinavia subsistence and economy were still based on hunting, fishing, gathering, and in some cases foraging activities. In southern Scandinavia, however, initial field systems, such as those of the Bronze Age site of Bjerre (northern Jutland), developed even further throughout Denmark. Similarly, there is also extensive saltmarsh and pastureland exploitation, as in the Assendelfder Polder (the Netherlands) and in northern Germany (Brandt and van der Leeuw, 1987).

Finally, people–wetlands interaction was also very much linked to sacred activity. Sacrificial offerings (objects, animals, humans), performed throughout the Neolithic and Bronze Age, continued, and in many cases (northern latitude

peatbogs) even intensified. Examples of bog sacrifices including weaponry, animals, and humans such as that of Skedemosse (island of Öland, Denmark) (Hagberg 1967) became quite common. Incidentally, it is the pre-Roman/ Roman period that is attributed with the highest number of bog bodies.

From AD 1 Onwards

Wetland occupation in Europe varied substantially from place to place during the past two millennia. There were areas with little or no sign of settlements, areas with fairly intense people–wetlands interaction but scarce evidence of settlements, and finally areas with both high exploitation of natural resources and dense occupation. In the Circum-Alpine region, for instance, after the disappearance of the long-standing lake-dwelling tradition at the beginning of the Iron Age, lakes and other wetlands alike remained virtually free of any occupation. This is not to say, of course, that interaction with, and exploitation of, wetland ecosystems (waterfowling, fishing, wetland vegetation, etc.) did not take place. During the Roman period, for instance, villas, *vicuses*, and military camps were certainly constructed near lakes, but not directly on their shores, or waterlogged areas. One of the best examples of such residential agglomerates, which has survived destruction thanks to subsequent water saturation, is the first-century *vicus* of Tasgetium, near Eschenz on the River Rhine (Switzerland) (Brem et al., 1999) (see also Ch. 4). In order to find another similar riverine occupation we have to step out of the Circum-Alpine region and go as far as the western Atlantic coast of France, and more precisely to De Losa, on the former course of the River Gourge. The Gallo-Roman site (first–third century AD) is submerged today (7 metres deep) by the recently formed Lake Sanguinet, whose shores were also occupied in the Late Iron Age (Maurin, 1998, 2006) (see the Iron Age section above). The first and only 'proper' lacustrine settlement within the Circum-Alpine region is the Medieval site of Charavines-Colletière, Lake Paladru, France, occupied at the very beginning of the second millennium (AD 1003–1040). The occupation consisted of three buildings (one 14 metres high) surrounded by a wooden palisade. People of Charavines-Colletière were farmers, fishermen, loggers, and carpenters, and they cultivated and ate cereals, as well as rearing and consuming a large amount of pork. The importance of horses detected within the settlement (quite a few artefacts such as iron bits, bridle-fittings, spurs, etc. have been found on site) has, surprisingly enough, not been confirmed by archaeozoological analyses, which have been able to identify only a few equine bones. Maybe the horses were only there temporarily (e.g. belonging to travellers). A number of valuable artefacts are also part of the archaeological assemblage, amongst them musical instruments, such as drums, flutes, and stringed instruments (Colardelle and Verdel, 1993).

A totally different picture of people's interaction with and occupation of wetland environments, from the Roman period onwards, is found in northern Europe, Scandinavia, the British Isles, and Ireland. In England for instance, the entire Roman period was characterized by a regression of the sea level, and evidence of occupation and exploitation of the wetlands is identified in various areas, such as the Fenland and the Humber Wetlands, and, of course, in a number of coastal as well as estuary environments. Van de Noort (2004*a*) lists a number of military sites (e.g. Rossington and Roall), villas (e.g. Drax and Cawood), and Romano-British settlements (e.g. Crowle and Adlingfleet) in the Humber Wetlands, pointing out their strategic location along rivers, whereas wetland resources such as salt were mainly exploited along the coast. A similar situation is found in the Fenland, where there too settlements were located on higher ground (e.g. fen-edges, islands, and marine silts—see Stonea Grange), and the salterns (Flaggrass, Middleton, and Upwell) in the lower areas (Hall and Coles, 1994*b*).

In Ireland settlements of this period (the first five centuries AD, and still considered Iron Age) are very scarce (O'Sullivan, 1998). Even the number of *toghers* in peatbog areas is extremely limited (Raftery, 1996*a*). It is only after this period that the typical Irish crannogs started to appear. The Scottish ones, on the other hand, are certainly present during this period, but mainly the south-western type. The Intertidal and Highland types are mostly Late Bronze Age and Iron Age (Henderson, 1998*a*, *b*, 2009) (see also Box 4.2, Ch. 4).

On mainland northern Europe, typical settlements of this period are the *terpen* (artificially elevated farmsteads in marshland areas), which are commonly found everywhere on the coasts, from the Netherlands to northern Germany. The most famous is that of Feddersen Wierde (north of Bremenhafen, Germany), occupied between the first and third centuries AD. The site was initially occupied in the last century BC (see 'Iron Age', above), but it was not typically elevated. It was only in the first century AD that the rising sea level forced the inhabitants of the farmsteads to build protective earthworks in order to prevent flooding. In the process, the various farmsteads were joined together to become a village. The site was eventually abandoned in the fifth century AD, when the climatic conditions worsened even further and living in the area became unsustainable (P. Schmid, 2002; Schmid and Schuster, 1999).

Climate change (it became wetter) and the rise in sea level of the post-Roman period also occurred in the British Isles, causing a considerable decline in occupation (Van de Noort, 2004*a*). A decrease in settlements in the wetlands did not, however, mean inactive interaction with them; economic activities (especially on slightly elevated areas) continued throughout this period. This Early Medieval occupational hiatus within wetland environments also occurred in the northern part of continental Europe, particularly in the coastal areas of the Niedersachsen (Lower Saxony), Germany (Strahl, 2004). The number of settlements started to increase again towards the end of the

first millennium AD, when the sea transgression began to recede. Meanwhile in Ireland, while the interaction of people with peatbogs diminished (note for instance the small number of *toghers*) (Raftery, 1996*d*), the number of crannogs on the lakes increased. Sites such as Moynagh Lough (Co. Meath), Ballinderry 1 (Co. Westmeath), Ballinderry 2 (Co. Offaly), Craigywarren (Co. Antrim), Lagore (Co. Meath), Rathtinaun—Crannog 61, Lough Gara (Co. Sligo), Colure Desmene Crannog, Lough Derravaragh (Co. Westmeath), and Bofeenaun (Co. Mayo) to mention but a few (all occupied between the sixth and the eleventh centuries AD), started a tradition of Medieval crannogs that continued throughout the Middle Ages, later developing into other forms of lacustrine occupations (e.g. *inis* settlements, marshland ringforts, mottes, and other kinds of fortification), which are typical of the Irish Medieval period (O'Sullivan, 1998, 2000, 2001*a*, *b*, 2007). Scottish Medieval crannogs, although present (e.g. Milton Loch 3, Lochrutton, and Ledmore), are, on the other hand, not as numerous as in Ireland (Henderson, 1998*a*).

Settlements on either natural or artificially enhanced lacustrine islands, contemporaneous to the western European Early and Middle Medieval period (but still part of the local Iron Age—see Fig. 2.1), are found in the north-eastern Baltic Sea regions, with some of the best known being Āraiši (ninth–tenth centuries AD) (Apals, 1993; Urtans and Rains, 2006), Ušuru (eighth century AD) and the pile-dwellings of Lake Valgjärv (ninth–tenth centuries AD). Although often compared with other terrestrial fortified sites, signs of fortifications within these settlements have not been identified (Roio, 2007).

Finally, an unusually large, square wooden platform, hollow in the centre, measuring 170 × 170 metres has been located on Lake Tingstäde Träsk on the island of Gotland (Sweden). The platform (also called Bulverket) with wooden houses on it was constructed in the shallow water of the lake and surrounded by a bulky palisade. The period of occupation was between *c.*AD 1000 and 1200. Because of its uniqueness in the region (no other such structures have been located in Sweden), and some similarities to a few sites in the eastern parts of the Baltic Sea regions (e.g. Estonia and Latvia), the building tradition of the structure is thought to have come from that area (L. Larsson, 1998).

The Late Medieval period was characterized by significant changes within the wetland landscape of northern Europe and the British Isles. The Late Medieval crisis was a combination of factors ranging from climatic deterioration to plague and famine, resulting in population decline and contraction of settlements. Although the crisis was, of course, felt within wetland communities, it is interesting to see how people, living within those areas regarded as marginal (e.g. coastal marshlands), responded with innovative strategies to cope with unexpected emergencies (Rippon, 2001*a*). Exploitation, modification, and transformation strategies (Rippon, 2000) were often involved throughout the Medieval period, but the drastic measures of landscape change were usually avoided.

Significant large-scale drainage in northern Europe and the British Isles began only in the seventeenth century. This inexorable process of land reclamation and wetland destruction continued through the following three centuries, detaching people more and more from the wetlands and creating a negative attitude towards them, which eventually influenced the way they are perceived in the present. Of course, this negativity did not involve all types of wetlands: riverine, lacustrine, and coastal estuary environments remained appreciated, and long-standing traditions of interaction with those ecosystems perpetuated through time until the present.

AFRICA
(see Maps 2 and 2A–B)

Africa's mostly warm climate may not facilitate the preservation of significant waterlogged archaeological evidence, but that certainly does not entail lack of people–wetlands interaction. In fact, people's relationship to wetland environments in this continent is amongst the oldest in human history (see e.g. Lake Eyasi, Olduvai Gorge, and Lake Turkana). It is difficult to say how today's permanent wetlands in Africa (about 1% of the continent's total surface) reflect those of the past, but it is certain that they always played a crucial role in human evolution and the formation of various cultural groups.

Wetland Environments

The majority of current wetlands in Africa consist of freshwater swamp forest, floodplains, mangrove forest and coastal lagoons, and herbaceous swamps (Denny, 1991; R. H. Hughes et al., 1992). Freshwater swamp forests consist of trees (e.g. *Pandanas candelabrum* and *Raphia* spp.) adapted to long periods of waterlogged soil. If rivers have distinct seasonal flood regimes, the species density is more developed. Such environments are found, for instance, in the Congo Basin, Lake Victoria, and the Niger Delta. Floodplains are the most common African wetland habitat, and are found near large lakes such as Lake Victoria and Chad, or near seasonally flooding rivers. Amongst the best known there are Mali's inland Niger Delta, the Okavango Basin (Botswana), the Barotse Plain, and the Kafue Flats in Zambia, and the Sudd swamps along the Upper Nile in South Sudan (Denny, 1991). All these areas are seasonally flooded grasslands, constantly influenced and modified by human activity (grazing and cultivation), but also rich in wild game. The vegetation follows the either wet or dry conditions, and it also depends upon the floodwater depth. Floodplains offer a variety of fauna, including fish and other aquatic

animals. As the waters retreat during the dry season, the environment changes, thereby modifying people's subsistence and economy.

Africa's tropical coasts and intertidal areas are dominated by mangrove forest. Some of the most extensive ones are found in the Niger Delta along the Atlantic coast, and from Angola to Mauritania on the Indian Ocean. The Korba lagoons of Tunisia and Lake St Lucia in South Africa have similar mangrove environments (R. H. Hughes et al., 1992). Herbaceous swamplands are mostly found on Lake Chad, the Upemba Lakes of southern Congo-Kinshasa, the Sudd swamps, the Okavango, and on Lakes Kyoga and Victoria. Usually these ecosystems consist of thick plant communities (most commonly papyrus), with, however, a fairly low density of fauna. Saline lakes such as Lake Eyasi, Lake Manyara, the Makgadikgadi saltpans in Botswana, and Chott Djerid in Tunisia, for instance, are also well-studied lowland wetlands, as opposed to those found at altitude (Ruwenzori and Usambara ranges and the Maloti Mountains in Lesotho), which have not as yet been thoroughly investigated. However, recent studies in the Rukiga Highlands in Uganda show the great potential these environments have to identify human adaptation and cultural change in Africa (Marchant, 2007).

Past Wetlands

Although wetlands were prized throughout the Pleistocene (see the various occupations around lakes and palaeolake basins, such as Lake Eyasi, Olduvai Gorge, Lake Turkana, and Olorgesailie; and what is possibly a throwing stick from the waterlogged deposits of Kalambo Falls in Zambia—about 400,000 years ago), it was from the Last Glacial Maximum (*c.*18,000 BP) that they become an essential part of people's existence. More systematic wetland activity developed, for instance, in the Nile's floodplains, which were 25–30 metres higher than today's levels. Hunter-fisher-gatherers of that area took full advantage of the rich fish and water plant resources, as the sites of Wadi Kubbaniya (Wendorf et al., 1989) and Makhadma 2 and 4 (Vermeersch et al., 2000) show.

Towards the end of the Pleistocene (*c.*12,000 BP) the 'Wild Nile' floods reduced the size of the wetland considerably and forced the Early Holocene hunter-fisher-gatherers to move upstream along the Blue and White Niles (Close, 1996). The development of new fishing technologies and the introduction of pottery (*c.*9500 BP) show a new phase of adaptation to the wetlands, from the Middle Nile to East Africa and across the Sahara (at that time, much greener after the return of the monsoons in the first part of the Holocene) (Barham and Mitchell, 2008). Evidence for a closer contact with the wetlands is also highlighted by the almost intact Dufuna canoe (*c.*7500 BP) found in Nigeria. This kind of watercraft was probably used on Lake Chad, which was

about 50 times larger than at present (Breunig et al., 1996). Fishing activities also became important in East Africa, where the major lakes were much larger than today; Lakes Elmenteita and Nakuru were joined together at some point, whereas Lake Turkana overflowed into the White Nile (Stewart, 1989). Good evidence of the importance of fishing activities comes from shell midden studies at Pundo, Kenya (Robertshaw, 1987). The fishing economy was complemented with other subsistence strategies, as is elegantly shown by the well-preserved material culture (windbreak post, grass-lined sleeping hollows, bow, arrows, and digging sticks) found at Gwisho Hotsprings (*c.*4785 ±70–3660 ±70 BP) in the Kafue Flat of Zambia (Fagan and van Noten, 1971: 22).

Farmers and herders began to inhabit Africa's wetlands as early as *c.*7000 years ago. Although continuous erosion and a combination of alluvial and colluvial deposits have covered the evidence, early agricultural settlements were already established around the Nile by the mid-Predynastic times. The Nile's annual flooding was not the same everywhere, and as a result, social complexity developed in different ways. For instance, a combination of intensive exploitation of aquatic fauna with cattle-keeping was preferred in the Mema Basin, although prolonged droughts forced people to switch to pastoralism by 2500 cal BC (Jousse et al., 2008). The Inland Niger Delta was occupied for the same reason by people forced to abandon areas that were undergoing processes of aridification (*c.*500 cal BC) (R. J. McIntosh, 1998). The wider floodplains of the Dongola Reach (Sudan) contributed to develop the Bronze Age society of Kerma (Kendall, 1997) and, later on (*c.*500 cal BC), the Kingdom of Kush (Ma'at-Ka-Re Monges, 1998) in a more decisive way. It is in such seasonally flooded environments that people started to develop new agricultural strategies (e.g. annual change of field location), which led to the formation of more complex societies (S. K. McIntosh, 1999*b*). Similar agricultural strategies in seasonally flooded areas are also found on Lake Chad (Breunig et al., 1996).

In some places (e.g. the Upemba Depression in the Congo-Kinshasa), social complexity resulted in the development of hierarchical societies, even before the end of the first millennium AD (S. K. Mcintosh, 1999*a*). Conversely though, we also have examples, such as the Ukara Island on Lake Victoria, where intensive wetland agriculture was carried out by non-hierarchical social groups (Ludwig, 1968).

Further evidence of floodplain cultivation is found in southern Africa. One of the best examples is the Limpopo River Basin, where important centres, such as Mapungubwe, Schroda, and K2, emerged in the first quarter of the second millennium AD, laying the foundations of the Zimbabwe Tradition (Huffman, 2007). Floodplain cultivation in the Limpopo River Basin is still practised today, but is threatened, unfortunately, by large-scale agricultural production, which, according to recent studies, is not suitable for the area (Silva et al., 2010) (see below).

Africa's wetlands, especially rivers and lakes, have also facilitated of communication and long-distance trade networks, with some of the best examples being the Nile, the Congo, and the River Niger, the latter playing a crucial role in the famous trans-Saharan trade (Mitchell, 2005).

Today's Wetlands

The age-old importance of wetland environments has continued to the present. The remarkable variety of wetland habitats (see above), and the still traditional way in which they are currently exploited, provide not only invaluable glimpses into ancient traditions but also vital perspectives for the future. The future of a large part of the African wetlands is in great danger because of their high sensitivity to cultural and environmental change. It is therefore crucial to identify where the threat comes from. What appears to have anthropogenic origins may also stem from environmental variability (climate change). Moreover, feedback between people and the environment can take different forms; it can be evident and straightforward (e.g. deforestation = erosion), or it may have delayed effects, such as changes in regional microclimates. For instance, one of the main drivers of recent environmental change in the Rukiga Highlands (Uganda) was the large-scale drainage of the low-altitude swamps, which resulted in a reduction of moisture (e.g. early morning mist) that triggered a localized regional climate change at higher altitudes (Marchant, 2007: 285).

Where the wetland environment is more dynamic (e.g. seasonally flooded areas), the relationship of the climate to cultural adaptation and change is even more precarious. For example, the farmers of the Mozambique's Limpopo River Basin have learnt how to cope with shocks, stressors, and risk caused by the periodical succession of droughts and floods, by adopting particular farming technique (e.g. seeding small plots of land), suitable for the area. Recent economic demand for higher agricultural production has altered the delicate relationship between people and land, because large-scale farming is not suitable for the area (Silva et al., 2010: 19–20). It has therefore become clear that old traditional environmental knowledge may assist modern rural societies to adapt, not only to the inevitable climate variations, but also to a more demanding global economy.

Glimpses into the past do not only concern subsistence and economy (traditional agricultural techniques to cope better with the modern economy), but also ancient architectural traditions of house construction still adopted by modern cultural groups. One of the best examples is the pile-dwellings of Ganvié, on Lake Nokoué in Benin. Here people still live in traditional wooden houses, especially constructed on stilts in order to cope with the seasonal fluctuations of the lake level. The resemblance of these modern settlements on

Fig. 2.5. Contemporary pile-dwellings at Ganvié on Lake Nokoue, Benin. (*Photograph*: courtesy of Pierre Pétrequin, Laboratoire de Chrono-écologie, CNRS, Besançon)

stilts to the prehistoric European pile-dwellings of the Circum-Alpine regions is striking (see Fig. 2.5).

Africa's preservation of the traditional people–wetlands relationship gives us the opportunity to study the liminal interface between present and past, enabling positive perspectives for future research. Considering that the wetlands are disappearing at an alarming rate worldwide, this is an opportunity not to be missed.

ASIA
(see Maps 3 and 3A–E)

Although the entire Asian continent has the potential of yielding significant wetland archaeological sites, only five areas, namely the Middle East (south-west Asia), Russia's Middle Urals region, the Russian far east, the eastern part of China (especially along the River Yangtze and its delta, the Chang Basin, and the Zhejiang region), and, of course, Japan, have been the focus so far of major wetland (or wetland-related) archaeological projects. The Middle Eastern regions of south-west Asia are particularly important for the study of palaeoclimatic variation (Develle et al., 2010; Six et al., 2008). In fact, except for the Marsh Arabs area in Iraq, the majority of sites related to

wetland environments at the time of the occupation are now in dry environments. These areas are particularly important for the study of past climate change, and for the distinction between former wetland and/or wet sites (see Ch. 1, under 'Wet or Wetland Sites?'). Palaeoclimatic change of a different kind can also be seen in the Middle Urals area of Russia, where interesting processes of lake terrestrialization similar to those in southern Scandinavia, during the Mesolithic (Chairkina, 2005; Zhilin, 2007) have occurred. The Russian far east is particularly crucial for the study of coastal communities such as those on the southern shores of Sakhalin Island and the Boisman Bay during the Atlantic–Sub-boreal period (Kuzmin, 1998). Interestingly enough, the main occupations occurred during sea level transgressions, rather than regressions. As was the case of Mesolithic communities on the Baltic Sea (see Europe—Mesolithic, above), also here, sea level transgressions were not seen as a threat but an advantage. A similar situation, although within riparian systems, is noticed along the River Yangtze and its delta (including the Chang Basin), where a shift of settlements from the surrounding elevated grounds to the lower plains started around 8000 cal BC, when cultural groups specifically linked to a wetland way of living began to develop (Feng et al., 1993). Finally, the richest area of Asia in terms of wetland archaeological research (and sites) is certainly Japan. Sites such as Yamaga, Kamei, and Ikejima-Fukumanji, for instance, are significant for the study of the Yayoi people's process of adaptation to the wetlands, and agricultural development in Japan generally (Matsui, 1992; Nishiguchi et al., 1984). The latter site in particular has shed new light on the progressive development of rice paddies and irrigation techniques (Inoue, 2001). Japan also offers invaluable examples of excavation strategies (e.g. the Lake Biwa cofferdam excavations) and cultural heritage management (see Chs. 5 and 9).

The Middle East (South-West Asia)

Because of its rather dry climate and seemingly arid landscape, one may think that wetlands never played a significant role in the Middle East (see Map 3A). However, a closer consideration of some important sites, thought not to have had anything to do with wet ecosystems, have revealed the opposite. In fact, from the heartland of Mesopotamia to the Anatolian Plateau, the Levant, Iran, and even Arabia, a large majority of well-studied prehistoric as well as historic settlements were closely linked to, if not surrounded by, wetland environments. Unfortunately, a series of palaeoclimatic variations (mainly a tendency to drier conditions) has transformed the physical landscape to the extent that any relationship of those sites to the surrounding wetlands has been almost completely erased. Only thorough palaeoenvironmental reconstructions in relation to on- and off-site archaeological analyses have been able

to reconnect those settlements to their 'real' contemporaneous (at the time of occupation) environment. A totally different scenario is offered by those wetlands formed as a result of climate change and/or human influence later on in prehistoric or historical times (see below). It is indeed thanks to these two types of site that the Middle East wetland archaeological research is able to offer a clear distinction between wet sites and wetland sites (see Ch. 1), which in other places (e.g. northern Europe and Scandinavia, or the Northwest coast of North America) may not be as evident. Another interesting aspect of wetland archaeological studies in the Middle East is the strong influence that people had on the development of some wetland areas, as was the case in southern Mesopotamia (Galili et al., 1993) and in southern Turkey (Wilkinson, 1997) (see below).

Climate proxy records (Develle et al., 2010; Lemcke and Sturm, 1997; Six et al., 2008) have demonstrated that during the Earlier and Mid Holocene, climatic conditions in the Middle East were somewhat wetter, and this, along with other hydrologic as well as human-induced transformation processes, have facilitated the development of marshland and swampy areas. Ancient wetlands have been recorded in a number of places, such as in Saudi Arabia (Garrard and Harvey, 1981), Yemen (Davies, 2006), and even the Arab Emirates (Parker et al., 2006). A combination of sea-level rise and the strengthening of the Indian Ocean monsoons in the Mid Holocene have also facilitated the development of wetter and more lagoon-rich coastal areas (Glover, 1998).

Although people's interaction with the wetlands in the Middle East probably started much earlier, the first apparent evidence comes from the Epi-Palaeolithic as it is confirmed by the remains of six brushwood huts found at Ohalo (*c.*23,000 cal BP) in the bed of the Sea of Galilee. In addition to the brushwood, the site yielded well-preserved charred seeds, fruits, wild wheat, barley, and acorns, along with plant fibres probably used with fishing technology (Nadel et al., 2004). A number of Neolithic and Chalcolithic sites previously situated in relatively dry coastal environments are now completely submerged. Two of the best examples are: the site of Atlit Yam off the Carmel coast, where twigs and tree branches as well as an impressive cache of 26,000 cereal grains have been found 300–400 metres offshore, and at a depth of 8–12 metres (Galili et al., 1993: 150); and the site of Kafar Samir (*c.*6000–4500 BC), which, on top of the olive wood and olive pits, has yielded well-preserved pieces of woven mats, baskets, and a wooden bowl (Galili et al., 1997). Interestingly enough, the development of those coastal marshlands was not due to the Early Holocene sea-level rise, but rather to the onset of a more humid climate (Sivan et al., 2004). In fact, sea water inundated the sites only after they had been totally abandoned.

As mentioned above, settlements that developed in close contact with wetland environments are today located in quite arid places, and the world-famous site of

Çatal Höyük (central Anatolia) is one of the best examples. Its surrounding wet environment would not only have provided a number of economic advantages, but also facilitated the transport of products in the area (Hodder, 2006). Evidence of basketry made of material collected in the nearby marshes does not come from waterlogged terrains though, but is instead recorded in impressions on plastered floors. A similar site, also developed in a marshy environment, is Tell Aswad in the Damascus basin (Van-Zeist and Bakker-Heeres, 1985). A series of Neolithic and Chalcolithic (between *c.*6000 and 3000 cal BC) sites, also located in a wetland context, are those situated in the Amuq Plain (southern Turkey) (Casana and Wilkinson, 2005). Of these, of particular interest are Tell Kurdu, occupied around the end of the sixth to early fifth millennium cal BC, the contemporaneous site of Imar, and the earlier settlement of Hassuchaği (Amuq phases A and B) (Yener et al., 2000). It is interesting to note that not all sites amongst those of the Amuq Plain were surrounded by wetlands. In fact, the Middle Bronze Age site of Qara Tepe was mainly located within a mix of dry and wetland environments. Sites that developed within marshy environments were also present in southern Mesopotamia, with one of the most significant being Tell Oueli (southern Iraq), occupied between 6500 and 4000 cal BC (Ubaid phases 0–4) (Huot, 1996). It is important to notice that some areas of the initial occupation (Ubaid phase 0) were seasonally inundated (Pournelle 2007: 45–47), whereas in the later phases the nearby terrains became drier and drier. The importance of the wetlands in southern Mesopotamia was not limited to the early villages (*c.*6900–6500 cal BC), but also during the development of the early towns, such as Eridu, Warka (fifth and fourth millennium cal BC), Umma, and Lagash (third millennium cal BC).

It has been noted earlier that marshland development was not only caused by changes in climatic conditions, but was also the result of human influence on the natural environment. An excellent example of wetland formation as a result of people influence is the development (in size) of part of Lake Antioch (Amuq Plain, southern Turkey). The excess of irrigation water collected from the Afrin River near the lake was not directed back to the river itself, but instead discarded into the small lake, hence increasing it size. Therefore, although a smaller portion of the lake existed throughout the Holocene, its actual size is only a recent (Iron Age, or later) development, due to human interference with the basin's hydrological balance (Wilkinson, 1997). Manipulation of river flows that resulted in the formation of extensive marshlands was also carried out by Babylonian and Assyrian kings, as confirmed by the vast swampy areas created around the city of Borsippa in the early sixth century BC (Cole, 1994). This kind of marsh formation caused by human agency also continued during later empires and, by the tenth to eleventh century AD, large areas of southern Mesopotamia had become covered in marshlands. It is not fully clear whether or not the marshlands of those days were appreciated; early Islamic texts describe them as negative places (Adams and Nissen, 1972).

Nevertheless, the Mesopotamian swamps (and people living within them) persisted until recent times, as is eloquently shown by Thesiger's book, *The Marsh Arabs* (1964).

As in various other parts of the world, also in the Middle East wetland sites are difficult to locate. However, the misleading appearance of the seemingly dry Middle Eastern landscape conceals rich evidence of an active people–wetlands interaction in the past. Lack of waterlogged sites should not discourage archaeologists from looking for new evidence, especially considering the fact that, as discussed above, some of today's wet sites may have little or nothing to do with ancient wetland environments; as opposed to a large number of existing dryland settlements, with a definite connection to wet ecosystems. The remarkable dynamism of the Middle Eastern palaeolandscape and its hydrological systems offer an outstanding platform for us to study the processes of change that are still affecting today's wetlands in many parts of the globe. It is perhaps by understanding those processes that we can prevent them from happening.

Eastern Russia

In the eastern part of Russia (the Urals, Siberia, and the Russian far east) (see Maps 3B and 3C), waterlogged wetland sites are not so numerous in comparison with European Russia (see the Europe section above). This lack of waterlogged archaeological evidence is due to a different choice of site location (which consequently influenced visibility) rather than to a lesser degree of people–wetlands interaction. There are nevertheless two areas where well-preserved waterlogged sites are fairly numerous: the Middle Urals and the Russian far east.

The Middle Urals Region

The Middle Urals region (also known as Middle Trans-Urals) (see Map 3B) is a low-elevation area between the higher northern and southern Urals ridges, particularly rich in peatbogs and lakes, which were part of much larger bodies of water. Slow processes of paludification and/or peat infilling covered (and preserved) prehistoric wetland settlements from the Mesolithic to the Late Bronze Age. People–wetlands interaction was not constant (especially concerning settlements) throughout the entire prehistory. Mesolithic sites were, for instance, not numerous, but the number increased in the Neolithic, Anaeolithic (Chalcolithic), and Bronze Age. More than 40 sites scattered around lakes, moors, and other water basins are known in the Middle Urals, with some of the best-researched being within the moors of Koksharovsky,

Gorbunovo, Ayatskoe, and Shigirsky, and on the lakes of Shuvakish, Vtoroe Karasye, Pervoe Karasye, and Moltaevo (Chairkina, 2005; Serikov, 1992; Starkov, 1980). One of the best-studied of the above-mentioned wetlands is the Koksharovsky Moor, with two sites: Koksharovsko-Yurinskaya 1 and 2, retaining multiple occupations from the Late Mesolithic–Early Neolithic to the Bronze Age (6470 ±80 to 3280 ±40 BP) (Serikov, 1992). Various sites have also been found in the Shigirsky Moor. Perhaps the most famous object found in this moor is the wooden figurine called 'Big Shigirsky Idol' dated to the Mesolithic (8680 ±45 BP) (Chairkina et al., 2001: 190). Other sites are from the Neolithic and Aneolithic: Yazevo 1 (Raushenbach, 1956: 92), Varga 2, Shigirskoe A (6045 ±64 to 4660 ±35 BP) (Chairkina, 2005: 26), Annin Ostrov (6730 ±160 BP) (Zaretskaya and Uspenskaya, 2007), and the Bronze Age site of Skvortsoskaya Gora 5 (Chairkina, 2005). Another well-researched area is the Gorbunovo Moor with two major sites: the Strelka (Raushenbach, 1956), dating to the Early Neolithic, and the Sixth Quarry (also called Section Six), retaining Anaeolithic, Bronze Age, and even Early Iron Age occupations (Coles and Coles, 1989; Starkov, 1980). A few more sites have been found on lakes and former lakes; amongst them two of the most noteworthy are Shuvakish 1 (Lake Shuvakish) and Rzboinichy Ostrov (Lake Vtoroe Karasye), which has yielded a remarkable finely worked Bronze Age birch-bark bag (Chairkina, 2005: 162).

The various, either continuous or intermittent, occupations in the Middle Urals wetlands were mainly dictated by climate and environmental variations. Recent studies show a succession of changes in climate, ranging from cold during the Boreal to milder conditions in the Early Atlantic, which continued until the Early Sub-boreal (*c*.4700–3900 BP) (Zhilin et al., 2007). Interestingly enough, contrary to what is often assumed, favourable climate conditions do not always coincide with occupation (see Ch. 3). For instance, while Strelka (Gorbunovo Moor) was indeed settled during 'good' climatic conditions and abandoned as the water-table rose, the later site of Sixth Quarry was deserted because of a drop in the lake level, which amplified the distance between the site and the lake shore, making the location less appealing (Bryusov, 1952; Sukachev and Poplavskaya, 1946).

Not only did the wetlands influence the location of the settlements, but they also shaped people's way of living and economy. Archaeobotanical and archaeozoological studies have identified diverse ways of subsistence according to different periods. For instance, within the predominant fishing activity throughout the Late Mesolithic and Early Neolithic, different stages of development could be discerned. From limited fishing during the Shigirskaya Culture people switched to a more intensive phase (with new fishing technologies), during the following Gorbunovo Culture. A subsequent drop in the water levels reduced the species of fish available, and hunting became more integrated into people's subsistence strategies (Raushenbach, 1956). Moreover, osteological analyses of waterfowl remains found at Koksharovsko-Yurinskaya 2 and

in the Shigirsky Moor have shown that aquatic birds played a pivotal role in the subsistence of the people of the Middle Urals throughout prehistory (Nekrasov, 2003). Dog bones were found as early as the Mesolithic, with the best example coming from the oldest anthropogenic layer of Koksharovsko-Yurinskaya 1. On the other hand, cattle and ovicaprid did not appear until the Late Bronze Age (Kosintsev 1988). Horse remains were rare, although some have been identified at Rzboinichy Ostrov (Chairkina, 2005). Whether or not the horses were domesticated still remains to be determined. Another unclear aspect of wetland economy in the Middle Urals is the adoption of cultivation; it is nevertheless believed that it did not start until fairly late (Bronze Age). On the other hand, evidence of metal production has been found with certainty at Sixth Quarry (Gorbunovo Moor), Skvortsoskaya Gora 5 (Shigirsky Moor), and Rzboinichy Ostrov (Lake Vtoroe Karasye) (Chairkina, 2005).

People–wetland interaction diminished considerably during historical time, but although settlements were by preference built in drier environments, traces of wetland exploitation (fishing and peat extraction) are still identifiable. Intensification of land reclamation from the Middle Ages onwards has, as in many other parts of the world, jeopardized those delicate wet ecosystems.

Russian Far East

The second area of eastern Russia fairly rich in wetland occupation is the Russian far east (see Map 3C). Here, three types of wetland sites are identified: coastal and estuary, lake-shore, and riverine (Kuzmin, 1998). Wetland occupation in the Russian far east is presumed to have started in the Late Palaeolithic, but the number of settlements began to increase only from the Neolithic onwards. It is interesting to see how, also in this region, occupational patterns follow climate and environmental changes, and are strictly linked to the morphology and hydrology of the various ecosystems—coastal and estuarine sites are amongst the most sensitive to climate change. For instance, the initial occupation of the Boisman Bay (*c*.6500–5000 BP) came to an end when, due to climate deterioration (colder conditions) during the Atlantic–Sub-boreal transition (*c*.5000–4500 BP), the sea level regressed, forcing people to seek new subsistence strategies inland (Verkhovskaya and Kundyshev, 1993). Subsequent climate amelioration during the Sub-boreal period (*c*.3000–2500 BP) caused settlements to reappear on the southern shores of Sakhalin Island and in the southern part of the Primorye. Here, the marine-based subsistence lasted until the beginning of the Sub-boreal (*c*.2500 BP), when, once again, people were forced to move inland during another sea-level regression (Krushanov, 1989). It is interesting to notice that both these periods of coastal occupation corresponded to marine transgressions, which were seen not as a threat, but as enhancers of rich subsistence resources.

Some of the most relevant wetland-related (although not waterlogged) sites in the Russian far east are located along the Amur River, showing long sequences of occupations. Gasya and Khummi were, for instance, occupied in the latter part of the Palaeolithic and Early Neolithic, whereas Suchu and Malaya Gavan were settled later, from the Neolithic to the Bronze Age (*c*.6000–3000 BP). People's subsistence here consisted of a mix of hunting and fishing, and evidence of agriculture does not begin until the Iron Age (*c*.2500 BP) (Krushanov, 1989; Kuzmin, 1995, 1998).

Unlike coastal groups, prehistoric riverine communities were not so much influenced by climatic change; their hunting, fishing, and gathering economy was less sensitive to environmental stressors. A slightly different picture is seen from the lacustrine groups. In fact, although their subsistence and economy was fairly similar to that of the people living along the rivers, the lake-dwellers (e.g. the site of Sinii Gai on Lake Khanka) were more vulnerable to environmental change, especially linked to water-level fluctuations.

Because of the vast extension (especially latitudinally) of the three abovementioned ecosystems, generalization is not possible, even within a single ecosystem. For instance, significant marine mollusc gathering and millet cultivation were practised only in the southern part of Primorye, and only in the Bronze Age and Iron Age (Brodianski and Rakov, 1992). Coastal occupation of the Russian far east is unique to the region; even the inland sites have their own characteristics that are different from those of the Middle Urals and European Russia discussed earlier.

China

The eastern part of China (see Map 3D), in particular the Huanghe (or Yellow River) lower valley and the Yangtze River Delta, is a rather rich area in terms of wetland occupations, from the Early Holocene to historical times. Due to an almost imperceptible difference between dryland and wetland sites, which may or may not result in waterlogged preserved archaeological evidence, the precise number of wetland sites in this region is difficult to establish. Early occupations (Late Pleistocene to Early Holocene) followed a fairly clear climate–environment pattern, which subsequently led to the establishment of characteristic wetland settlements such as the pile-dwellings. After an initial expansion of flooded areas in the Late Pleistocene, the waters started to retreat at the beginning of the Holocene (Fang, 1991; Feng et al., 1993). As a result we notice a shift of settlements from the surrounding elevated grounds to the lower plains. It is indeed from that time (*c*.8000 cal BC) onwards that series of cultural groups specifically linked to a wetland way of living began to develop. The first cultural group was the Shangshan (*c*.8000–7000 cal BC), and it was

followed by the Kuahuqiao (*c*.6000–5500 cal BC), the Majiabang and Humudu (*c*.5000–3800 cal BC), the Songze (*c*.3800–3300 cal BC), the Liangzhu (*c*.3300–2300 cal BC), the Guangfulin (*c*.2300–2000 cal BC), and finally the Maqiao (*c*.2000–1500 cal BC), which preceded the historically documented Shang state (Chang, 1986; Gao, 2005; Lin, 1998).

Thanks to excellent preservation, there are sites that prove that settlements were often constructed on stilts, displaying a very accomplished carpentry (Zhao and Wu, 1986–7). Some of the best examples are found at Tianluoshan and Hemudu, which both show a remarkable display of mortise and tenon joints; notable also is the wooden ladder, accompanied by a nearly 6-metre long dugout (the oldest of the region, *c*.5000 cal BC) and two paddles found at Kuahuqiao (Jiang et al., 2004). Evidence of pile-dwelling constructions has been found not only in the form of waterlogged wooden remains, but also houses on stilts were depicted on pottery (e.g. at Xiantaimiao) (Wang, 2007). Houses on stilts were mainly rectangular, but there is also evidence of round dwellings with sunken floors found on the foothills of higher areas in the middle Huanghe valley. A variety of artefacts was found in almost all waterlogged sites; from wooden adze handle and spades to fish-hooks, awls, hoes, weaving shuttles, mallets, and spears made of animal bones. Pottery was also present, but it was fairly simple, and it was mainly decorated with cord impressions. Food was harvested from the surrounding wetlands as well as from the more elevated woodlands, and it consisted of nuts (acorns and water chestnuts), aquatic animals (water deer, alligators, tortoises, and turtles), aquatic waterfowl (ducks, cormorants, herons, and cranes) and fish (mainly catfish and carp). A large quantity of wild and domesticated rice (*Oryza sativa*—mainly *sinica* and *japonica*) was also found on almost all settlements. This has also contributed to the incandescent debate, as to when rice was first domesticated (Barker, 2006) (see also Ch. 7). Millet (both foxtail and broomcorn) was also widely used, along with rice, since it was particularly adapted to dry winters and wet summers. Rice was already part of people's diet even before the vast flooded areas of the Yangtze River Delta were settled. One of the oldest indications of rice use (perhaps cultivated) the Yangtze River lower valley was found in the pottery clay (used as temper) at Shangshan (*c*.8000–7000 cal BC) (Jiang, 2007; Jiang and Liu, 2006).

Once the great wet plains were colonized, paddy fields became quite common (e.g. the sites of Caoxieshan and Choudeng, *c*.4000 cal BC). Recent studies at Tianluoshan have also identified paddy fields associated with walking paths used to link the various cultivated areas. Interestingly enough, these paths were not built of wood (see Europe above), but of compact soil paved with silica or calcium-containing deposits (Zheng et al., 2007).

Subsistence and the economy of the Yangtze River lowlands prehistoric populations was not only based on rice cultivation. In fact, as the site of Tianluoshan shows, rice production was often not enough to sustain the entire

population, and people adopted alternative subsistence strategies (hunting, fishing, and gathering) (Fuller et al., 2009).

Later Neolithic (after *c*.5000 cal BC) settlements in the Yangtze valley and surroundings continued in the same way as before, as is shown by the similarity of the pile-dwellings of Majiabang to those of Hemudu. Material culture and the way of life did not change substantially, except for the full adoption of wet rice cultivation, which became more widespread. An exception to the rule is the Yangzhou sites (towards the north, in the Huanghe valley), where a marked progression in complexity is noted. The settlements of Jiangzhai and Banbo (*c*.5000–3000 cal BC) were for instance much larger, and thoroughly planned. Houses, built in a circle round a communal central space, could be round or square, but were no longer on stilts; instead, they had plastered floors cut into the loess subsoil. Subsistence based on hunting, fishing, and gathering was still present, but millet cultivation and pig breeding certainly prevailed. The sites also yielded remarkable evidence of skilful basketry making, cultivation of silk-worms, and even pottery, which was made using the slow wheel (Chang, 1986). The settlement layout and the carefully planned cemetery outside the village indicate an orientation towards social stratification and economic intensification, which eventually developed into the Shang state.

Despite the tendency to build settlements on drier ground, people–wetlands interaction (especially concerning rice cultivation) continued throughout historical time. However, although waterlogged archaeological evidence is still present, it becomes more and more limited, as a result of intensive field cultivation and/or the lowering of the water-table, which jeopardizes the preservation of organic material. Prehistoric anthropogenic layers are, on the other hand, buried much deeper and survive better.

The numerous known, but unfortunately still not entirely researched, waterlogged sites in the Yangtze River Delta and the Huanghe valley have great potential. Not only could they shed light on the region's prehistory, but they could also contribute some answers to crucial questions concerning food production and economy in East Asia.

Japan

Although shell middens (e.g. the Omori site, Tokyo) had already been excavated and researched in the second half of the nineteenth century (Morse, 1879), it was not until the discovery of the Korekawa site (Hachinohe City) in the mid 1920s (Kono, 1930) that the potential of waterlogged archaeological sites in Japan (see Map 3E) was realized. More sites of crucial importance came to light in the pre- and post-World War II periods, but the real boom in discoveries started in the 1960s and 1970s with the increase in

rescue excavations, brought about by the favourable development of Japan's economy (Matsui, 1999). Three of the most important sites that led to the development and great achievements of wetland archaeology in Japan are the Torihama shell midden (Lake Mikata), discovered in 1962, the multi-occupation site of Juno (Omiya City) found in 1979, and, more recently (1980s–1990s), the submerged (but excavated with the cofferdam technique) sites of Awazu on Lake Biwa (Maruyama, 1984; Matsui, 1992, 1999).

Although evidence of lacustrine campsites (e.g. Tategahana, Lake Nojiri, and Tomizawa, Sendai City) (Nakamura and Kondo, 2005; Saino, 1992) starts as early as the Lower Palaeolithic, the majority of wetland sites occurred in the Holocene, especially from the Early Jomon period onwards (see Table 2.2).

The Jomon period (12,000–2400 BP) is characterized by hunter-fisher-gatherer groups with pottery (the oldest pottery in Japan), but not significant agriculture, as opposed to the Yayoi period (400 BC–AD 300) during which agriculture developed considerably, especially concerning wet rice cultivation. The Kufun period marks the transitional period between prehistory and history, and it is the time of great burial mounds, also known as the keyhole-shaped tombs (Matsui, 1999). From the climate point of view, the Japanese Holocene started with a cold phase (*c.*12,000–10,000 BP), when deciduous forest dominated the landscape. The climate became gradually warm from 10,000 BP onwards, reaching the warmest phase between 6000 and 4500 BP, when evergreen broadleaf forests replaced the deciduous ones.

Table 2.2 Chronology of Japanese prehistory (Source: Matsui 1999: 148)

Period	Phase	Date
Palaeolithic	Lower Late	?150,000–30,000 BP 30,000–12,000 BP
Jomon	Incipient	12,000–10,000 BP
	Initial	10,000–7000 BP
	Early	7000–4500 BP
	Middle	4500–3500 BP
	Late	3500–3000 BP
	Final	3000–2400 BP
Yayoi	I	400–250 BC
	II	250–100 BC
	III	100–1 BC
	IV	AD 1–100
	V	AD 100–300
Kofun	Early	AD 300–400
	Middle	AD 400–500
	Late	AD 500–600
	Final	AD 600–700

One of the richest and best-researched wet/wetland archaeological sites of the Jomon period is the shell midden of Torihama. It was occupied between 10,000 and 4,500 BP, although most of the abundant material comes from the Early Jomon phase (7000–4500 BP). The settlement (3–4 houses) was located on the upper terrace of Lake Mikata, whereas refuse was thrown and accumulated in the shallow water of the lake near the shore. The archaeological assemblage is fairly rich and varied, ranging across bowls, axe hafts, paddles, lacquered ware, and wooden building material. Botanical remains (e.g. green beans, hemp seeds, bottle gourds, and a large quantity of acorns and walnuts) as well as animal bones (freshwater shells and fish, wild boar, and sika deer bones) were also quite abundant. The site also yielded cordage, human and dog coprolite, red-lacquered combs, and two dugouts of the Early and Middle Jomon period (Matsui, 1999; Morikawa and Hashimoto, 1994; Yonemura, 1983). Another site with rich anthropogenic layers of the Jomon period is Juno (6000–2300 BP, Middle to Final Jomon). Plant and animal remains are typical of the Jomon period, but in Juno they were not as abundant as in Torihama. On top of the sealed (by alluvial sediments) Jomon layer, there were other occupations, belonging to the Yayoi and Medieval times. One of the most impressive cofferdam (caisson) excavations in Japan is that of Awazu on Lake Biwa (see Ch. 5, under 'Cofferdam Excavation Technique'). The site was occupied between 9500 and 4500 BP (Initial to Middle Jomon), and consists of three large shell middens with a variety of typical Jomon remains (Iba, 2005; Matsui, 1992). Other important Jomon sites are: Higashimyo shell midden (Early Jomon) (Nishida, 2010); Sannai Muruyama (famous for the massive wooden posts (> 1 metre Ø), the large number of bone and antler artefacts, woven fabrics, seed of crimson glory vine (*Vitis coignetiae*), and hardy kiwi (*Actinidia arguta*), occupied in the Middle Jomon period); Ondashi (Early Jomon); Sakuramachi (Early to Final Jomon) (Matsui, 2009); Shimoyakebe (Late to Final Jomon) (Chiba, 2009); Tsukuda (Middle to Final Jomon), and Saragawa (Early to Middle Jomon) (D'Andrea et al., 1995; Miyaji, 1999). Finally, the two sites of Shidanai and Mawaki (Yamada, 1986) (discussed in Ch. 4, see under 'Weirs and Fish-Traps' and 'Ritual Architectural Structures') also included weirs and unusual wooden pile circles.

The Yayoi period marks the beginning of systematic cultivation, in particular rice field systems, which developed from small units in the Yayoi phase I (400–250 BC), to complex irrigation networks from phase II (250 BC) to phase V (AD 300) (Imamura, 1996*a*, *b*; Inoue, 1999). Amongst the number of Yayoi sites located in the Osaka Plain, three in particular, Yamaga, Kamei, and Ikejima-Fukumanji are of great interest for the study of agricultural development in Japan. Yamaga dates from the Early to Middle Yayoi (phases I–III), whereas Kamei's chronology is even longer, continuing until the beginning of the Kofun period (Matsui, 1992; Nishiguchi et al., 1984). The sites are also significant for the study of Yayoi people's adaptation process to the wetlands,

not only from an environmental perspective but also concerning subsistence and economy, during the Jomon–Yayoi transitional period. The extensive excavation of the Ikejima-Fukumanji site provides new information about the progressive development of rice paddies, including irrigation, field size, and cultivation techniques (Inoue, 2001). Other sites that are also important for a better understanding of irrigation systems involving wooden dam construction are those of Naka Kyuhira, Hyakukengawa (Yayoi, phase V), and the Early Kofun period (AD 300–400) site of Kodera (Inoue, 1999; Matsuyama City Board of Education, 1976). Although the interpretation of the Kofun period paddy field systems is certainly central to the formation process of the Jouri grid-like field system of the seventh–eighth century AD, it is by recognizing the socio-economic significance of the Yayoi block of fields and their irrigation facilities that the entire development of the later Jouri grid-like field system can be fully understood (Barnes, 1993). In fact, as demonstrated by land-use transformation analyses at Ikejima-Fukumanji, the management of the irrigation system is closely related to the agricultural communities' social organization; studying the former will therefore shed light on the latter (with all the consequent developments) (Inoue, 1999). It is finally important to point out that rice cultivation during the Yayoi period was not only practised in the southern part of the Honshu Island (including Kyushu and Shjikoku islands) of Japan (as demonstrated by the majority of archaeological sites; e.g. Toro, Naka Kyuhira, and Hyakukengawa, to mention but a few), but also at a few sites such as Sunazawa and Tareyanagi, which had also appeared in the north, by the last stage of the Early Yayoi period (phase I) (Hudson, 1990; Pearson, 1992).

Waterlogged (or semi-waterlogged) archaeological contexts have also yielded remains of ancient towns, dating from the Final Kofun period throughout the Middle Ages and up to pre-modern times. Of particular importance is for instance the Kurumidate site (early tenth century), which yielded entire residential buildings, wooden tablets (regarded as documents of the central government at the time) and a variety of pottery (Nara National Research Institute, 2008); the thirteenth- to sixteenth-century town of Kusado Sangen Cho (an important port of trade on the River Ashida); and finally, the large number of artefacts belonging to the seventeenth- to eighteenth-century Ainu Culture found at Bibi 8, near the Misawa River (Chitose City, Hokkaido) (Hokkaido Maizou Bunkazai Senta, 1996, 1997; Tezuka, 1998).

Wetland archaeology in Japan has made remarkable progress since the law for the protection of Japan's cultural heritage was passed in 1952. A common agreement between archaeologists, government, and developers has, since then, facilitated the completion of a large number of extensive and expensive wet/wetland excavations, which have yielded remarkable evidence of Japan's rich cultural heritage from early prehistory to the present. Japanese people's

respect for their past as well as their responsibility to protect it should be an example for all of us to follow.

OCEANIA
(see Maps 4 and 4A–C)

Wetland archaeological sites in Oceania are mainly found in the New Guinea Highlands, Australia, and New Zealand (*Aotearoa*). Both the New Guinea Highlands and Australia have notable traces of people–wetlands interaction. See, for instance, the remarkable example of prehistoric agriculture at Kuk Swamp (Papua New Guinea) (Denham et al., 2003; Golson, 1990; Gorecki, 1985, 1986), the pre-European Aborigine occupation of the southern Victorian swamps in Australia (Lourandos, 1987), and the extraordinary traces of the oldest human cremation in the world at Lake Mungo (New South Wales). Some of the most momentous wetland discoveries of the Southern Hemisphere are, however, to be found in New Zealand, which has been experiencing a remarkable increase in wetland archaeological research recently. The latest discoveries have confirmed the importance of wetland environments in the development of the Maori Culture, since the very first human occupation of *Aotearoa*, *c.*AD 1000–1200 (Anderson, 1991; Davidson, 1984). New Zealand is renowned not only for its well-researched wetland sites, but also for the use and development of advanced scientific methods in wood conservation (see Ch. 5).

New Guinea

Despite their limited waterlogged archaeological evidence, the Highlands of New Guinea (including both Irian Jaya and Papua New Guinea) (see Map 4A) are crucial for the understanding of agriculture development in south-east Asia and Oceania in general. An outstanding example of Early Holocene landscape manipulation for agricultural activity in wetland environments is the Kuk Swamp, situated in the upper Wahgi valley of Papua New Guinea. Archaeological evidence of agricultural activity spans from *c.*10,220 cal BP to about 100 years ago and is represented by two kinds of features: planting areas (e.g. small elevated mounds, separated by basins and ditches), and drainage channels, to remove the excess of water. The entire period consists of six phases, which themselves fall into two main groups: the drainage period (phases 1–3), and the development of pig-centred society (phases 4–6) (Bayliss-Smith and Golson, 1992*b*; Golson, 1990).

Archaeological evidence of phase 1 dates from *c.*10,220 to 9910 cal BP, and consists of stake-holes, post-holes, and pits on elevated levees, near a

palaeo-channel (Golson, 1977). Agricultural activity in the first phase is interpreted as shifting cultivation (on the edges of a swampy area) of a variety of plants, within which taro (*Calocasia esculenta*) seems to have prevailed. Phase 2 (*c.*6950–6440 cal BP) consists of a series of circular/subcircular regularly distributed mounds that included stake- and post-holes (Denham, 2007; Denham et al., 2003). The creation of these better-aerated soil surfaces is interpreted as an increasing commitment to taro. Phytoliths of banana (*Musa* spp.) advance the possibility that this plant was also cultivated at Kuk during that time. Only about one hundred years separate phase 2 from phase 3, which itself is divided into two periods: first *c.*4350–3980 cal BP, and the second *c.*3260–2800 cal BP. Archaeological evidence of this period consists of a significant network (about 2 km long) of ditches, which too, were used for taro and banana cultivation (Denham, 2005; Denham et al., 2003, 2004, 2009). Phase 4 (*c.*2300–1250 cal BP) is characterized by a progressive intensification of wetland production, and by the onset of the pig-centred societies of the Modern period. The ditches join each other at right angles forming a grid pattern of small rectangular (occasionally square) fields, measuring on average 8.8 × 12.2 metres (Bayliss-Smith, 2007). These fields and drainage channels, however, were not in use simultaneously. The adoption of deliberate swamp fallowing could have had a number of advantages. For instance, it is believed that it would probably have facilitated the removal of taro beetle infestation, which, although less significant than in other, drier deforested areas, was a major issue in wetter environments. Similar ditch and field systems have recently been observed near Tambul in the upper Kaugel valley (Bayliss-Smith, 1988). The intensification of taro production, also known as the Colocasian Revolution, of phase 4 produced new surplus, which initiated new social relations and the development of more complex exchange networks. This also stretched the limits of egalitarian relationships of co-operation within the community, and brought about the emergence of the so-called 'big men'. Tension between them and their rivals, and/or their labour suppliers (who were being overexploited) could have arisen, triggering socio-economic instability and periods of belligerence (Bayliss-Smith and Golson, 1992*a*; Spriggs, 1990). Phase 5 (*c.*450–280 cal BP) is the least understood of the entire Kuk swamp sequence. It is, however, believed to have been an important transitional period between the taro-based systems and the pre-sweet potato (Golson, 1982: 132). The final phase (phase 6), starting around 280 cal BP and finishing about 120 years ago, was characterized by the arrival of the sweet potato (*Ipomea batatas*). Although first introduced from South America *c.*AD 800, it was not until the European colonial context, about 400 years ago, that this crop started to be exploited significantly, giving the period the appellative of 'Ipomean Revolution' (Barker, 2006; Golson, 1982, 1989).

It is interesting to notice that, except for the above-mentioned archaeological evidence (e.g. stake-holes, post-holes, pits, and drainage channels), traces

of agricultural tools and houses within the wetlands are not present until very late (Bayliss-Smith and Golson, 1992*b*). However, single- and double-ended paddle-like implements, similar to those used today in taro cultivation, have been found at Tambul (the oldest one from 3930 BP, Bayliss-Smith and Golson, 1992b: 19) in the upper Kaugel valley (Papua New Guinea) (Golson and Steensberg, 1985), and also noticed in use in the Baliem valley of Irian Jaya in the 1960s (Heider, 1970).

The more abundant archaeological evidence found in the eastern part of the New Guinea Highlands begs an obvious question: was wetland agricultural activity also present in other parts of the New Guinea Highlands? If we supplement the limited amount of waterlogged archaeological evidence with proxy data obtained from geomorphological, palynological, and also ethnoarchaeological studies (Gorecki, 1986; P. J. Hughes et al., 1991; Powell, 1982), the answer is certainly 'yes'. In fact, the sequence of vegetation in the Baliem valley and the management of benched landscapes in the Arona valley and even in the lowlands around Lake Hordorli, suggest that the Kuk swamp phenomenon was certainly not a sporadic event (Gillieson et al., 1985; Golson and Gardner, 1990; Haberle et al., 1991; Hope and Golson, 1995; Hope and Tulip, 1994). Although probably not connected with that of the Highlands, wetland agricultural activity is also present in the lowlands. Raised linear mounds are found in the Fly Estuary (southern Papua New Guinea), on the Kolepom Island (Irian Jaya), and on the Amogu floodplains in the Middle Sepik area (northern Papua New Guinea) (Hitchcock, 1996; Swadling and Hide, 2005). It is interesting to note that it was in the wetland lowlands where eighteenth- and nineteenth-century explorers noticed that people were living in houses on stilts (e.g. on Lake Sentani, the Humboldt Bay, and the Bay of Doreh) (Petréquin et al., 2006). Some ethnographic accounts (e.g. from the Bay of Doreh) of that time were later used by Keller to prove his theory (Kaeser, 2008*b*) (see Ch. 1).

The archaeological evidence of early agricultural activity in the New Guinea Highlands is not only crucial for the study of the development of wetland cultivation in the tropics (see also 'Central and South America', below), but also for the confirmation, or indeed rejection (as far as New Guinea is concerned) of the demic diffusion model (also referred to as the 'Express Train model'), whereby Austronesian-speaking Neolithic groups colonized the Pacific, starting from mainland China and moving southwards and eastwards (Bellwood, 1996, 1997; Bellwood and Renfrew, 2002). In fact, archaeological as well as palaeoenvironmental evidence seems to disagree clearly with the hypothesis that taro cultivation reached the New Guinea Highlands with the Austronesian colonists, around 5000/4000 cal BP. Instead, a much earlier emic development of that kind of crop within rather wet environments seems to be a more plausible explanation (Bayliss-Smith, 1996; Bellwood, 2005; Denham et al., 2004).

Australia

While not particularly common, Australian wetlands (see Map 4B) have always played an important role in Aboriginal settlement and subsistence. Since the first colonization of the continent, people's interaction with the wetlands has followed rather irregular patterns that mirrored long-term as well as seasonal climatic variations. As a result, when studying people–wetland interaction in Australia, one has to distinguish not only the different chronological periods, but also geographical regions. Wetlands from the north are substantially different from those of the south, as much as coastal wetland areas vary from the inland ones. Archaeological sites in relation to wetland environments are not particularly abundant in the Pleistocene and Early Holocene, whereas they increase significantly from Middle to Late Holocene. Interaction and use of the wetlands continued during the (European) Contact period and up to the present.

The colder and wetter climate of the Pleistocene (about 50,000 to 15,000 years ago) facilitated the development of riparian gorge systems and lakes, which are thought to have been crucial to people's movement around the continent (Veth, 1989). Stone artefacts of this period have been found on Lake Gregory (Western Australia) (Veth et al., 2005), Lake Mungo (New South Wales) (the oldest human cremation and ochre burial in the world, *c.*40,000 BP) (Bowler et al., 2003), around Lake Tandou on the lower Darling River (New South Wales) (Balme, 1995), at Cuddie Springs (Field, 2006), and finally at Kenniff Cave within the Great Artesian Basin (Queensland) (Flood, 1990).

From the Late Pleistocene to the Early Holocene (*c.*15,000 to 7000 BP), the climate improved, the environment became more diverse and the number of wetlands (in particular swamps) increased. It is indeed in this period that the Murray-Darling Basin formed. Sites on Lake Tandou increased in size and we have the establishment of some cemeteries (namely Coobool Creek, Roonka, and Kow Swamp) along the Murray River (Pardoe, 1988). One of the first direct evidences of wetland occupation comes from Wyrie Swamp, a peatbog of southern Australia. Here, 10,000-year-old wooden implements, such as spears and boomerangs, and stone artefacts were located around the edges of the bog (Hiscock, 2008). During the first occupation the swamp was fairly small, but, by 9000 BP it increased in size, covering previous sites. The swamp was abandoned around 8000 BP.

From the Middle to Late Holocene (*c.*7000 to 200 BP) archaeological evidence of wetland occupation increased significantly. In the north, down-cut river valleys began to be flooded and invaded by mangroves, which subsequently disappeared, creating a mix of freshwater and estuary areas between 4000 and 2000 BP. The monsoonal system that creates vast freshwater wetlands today had already developed by 2000 BP (Brockwell, 2009). It is interesting to note how the archaeology of the northern regions (e.g. Arnhem Land)

has followed the development (long-term and seasonal) of the floodplains. People gathered more around the wetland edges to exploit their rich resources, as is shown by the large concentrations of stone artefacts along the Mary and Alligator Rivers (from 1000 BP onwards). It is during this period that the earth mounds (characteristic features of the wetlands) around the floodplain margins of the Blyth, Adelaide, and Finniss Rivers developed (Brockwell, 1996). In the southern part of the continent, wetland ecosystems were more diverse, ranging from upland bogs and mires to riparian flood, and coastal or subcoastal wetlands. As in some parts of northern Australia, also along the upper Murrumbidgee valley and within the Macquarie Marshes, earth mounds were the most common site type. This particular type of occupation is often associated with the wetlands, and is usually located on naturally elevated ground within poorly drained areas. In both the north and south of the continent mounds began to be built around 4000 BP, although the majority of them are less than 1500 years old. As for their function, the debate is still open. Some scholars believe them to be part of the settlement's strategy to cope with local flooding (E. Williams, 1988), others argue for overlapping functions, ranging from camp sites to ovens and bases for shelters (Brockwell, 2009). In the south, the number of possible functions is higher, including those of gardens, ceremonial centres, burial mounds, ovens, and ash dumps (Frankel, 1991). In northern Australia ethnographic evidence shows that mounds may even have acted as cultural markers, with significance in relation to Dreamtime mythology (Brockwell, 2009; Roberts, 1994). It is also believed that earth mounds dictated patterns of settlements in relation to mobility strategies. In other words, they were not simply environmental adaptations to occupation and social exploitation of inundated areas, but also the result of change in mobility strategy linked to social organization (Lourandos, 1983; E. Williams, 1988). There are other scholars, for instance Head (1990), who firmly argue against sedentism and increase in production. The occupation of mounds is more linked to population relocation to areas of richer resources such as the wetlands. Mound occupations are therefore seen as adaptations to wetter conditions beginning around 2500 years ago (Bird and Frankel, 1991). Finally, due to the scarcity of archaeological evidence, it is much more difficult to determine whether earth mounds were overnight camps or more permanent base camps. However, the presence of specific stone-working technology found along the Alligator River suggests lower residential mobility (Hiscock, 1996).

Within the last two hundred years we have a much more detailed description of people–wetlands interaction. It has to be taken into account, though, that these historical and ethnographical accounts were all written after a major population dislocation from the Aborigines' own land. A distinction between north and south can, however, be made. Large gatherings of people in the north were seen as a wide range of specialized equipment for the exploitation

of the wetlands, which occurred mainly during the dry season (October–December), or the late wet season (March–April). In the south, on the other hand, flooding of wetland areas occurs in winter (June–August), and the summer is usually dry. Seasonality of resources also affected mobility. Winters were periods of hardship and people gathered in semi-permanent villages, such as those recorded near Lake Bolac. Summers, on the other hand, were periods of abundance of wetland resources and people were more mobile (e.g. during hunting or trade activity) (Gaughwin and Sullivan, 1984).

Wetland ecosystems have always played an important role for the Aboriginal people in terms of subsistence, settlement patterns, and mobility. Their seasonality (in both the north and the south of the continent) did not make wetlands a reliable source of food or water. As a result, people occupied their margins but still remained linked to more permanent food resources. During periods of peak productivity, however, wetlands were able to support high populations of hunter-gatherers and also offered opportunities for gatherings of different groups. For how long the gatherings took place, and how large the population was depended upon the size and location of the wetlands. The historical model of wetland use—whereby campsites were clustered along wetland edges (to take advantage of the wetland resources)—has also been confirmed by archaeological evidence.

The vast geographical extension of the Australian continent and its long-term as well as seasonal climatic variations clearly highlight the importance of the wetlands, from the initial colonization, to megafauna extinction, and finally to demographic increase in relation to subsistence and environmental factors. As a result, Australia offers a unique opportunity to show that wetland archaeological research is not always linked to waterlogged (archaeological) remains, but expands far beyond it.

New Zealand (*Aotearoa*)

The wet and temperate climate of *Aotearoa* (see Map 4C) has always facilitated the development of a variety of wetland ecosystems. Before the onset of modern agriculture and drainage, large areas of wetland covered the three main islands of ancient *Aotearoa*, ranging for instance from the more than 500 sqkm of the Hauraki Plains to the small and very localized swamps of Taranaki (Buxton, 1991). As a result, the Maori's interaction with the rich wet landscape has always been very active, since the islands were first colonized about 1000 years ago. This active relationship is reflected in the rich variety of waterlogged archaeological evidence found in former as well as current wetland environments. Although they could potentially be located everywhere in the country, the large majority occur in the North Island (Gumbley et al., 2005). Wet archaeological sites in New Zealand can broadly

be divided into two main categories: settlements and artefact finds or caches. The first category includes the *pa*, a sort of fortified village usually located in swamps, on river banks, and at shallow lakes (see Ch. 4), whereas the second category consists of isolated artefacts and/or house structures intentionally buried in wet contexts.

Buried Artefacts

A typical custom of the Maori people living in the wetlands was that of burying artefacts with the intention of retrieving them later. This is not to say that all artefacts found in wetland archaeological contexts were intentionally interred, some of them were, of course, accidentally lost or deliberately disposed of. A large number were, however, buried with one of two intentions: to retrieve the objects later, or as permanent burials. Unlike prehistoric peoples in Europe, the Maori's burying of objects was not linked to votive offerings. Although the wetlands were symbolically meaningful to the Maori, artefact burials are regarded as being mainly functional. There are various theories as to why objects were temporarily buried; seasonal storage, curing and seasoning, softening for facilitating carving, and/or concealment from an enemy (Phillips et al., 2002). A few wet sites, such as Kauri Point and Te Miro, do, however, show evidence of permanent interment. Kauri Point yielded a large number (187) of finely made hair combs, deliberately broken and deposited on an artificially constructed floor. The large number of them and the length of the timespan covered have contributed to the identification of important changes in Maori material culture (see also Ch. 4). The broken combs and the unusually high number of obsidian flakes (about 14,000), led archaeologists to believe that the site could have been used as a repository (regarded as *wahi tapu*—sacred site) for ritually damaged items discarded by people living in the nearby *pa* (Shawcross, 1976). Also Te Miro shows a case of object burial with no intention of recovery. Here, part of a 14-metre long Maori Parliament House (*Kauhanganui*) was interred when the site was abandoned, following an influenza epidemic in the 1890s. This site was also regarded to be a *wahi tapu* (Edson, 1979; Phillips et al., 2002). Sites with a certain functional purpose are fairly numerous and two of the best examples are Kaikohe and Waitore. Kaikohe (occupied in the late eighteenth century) yielded a series of agricultural wooden objects deposited underneath a network of branches probably used to keep them in place. It has been assumed that the objects were deposited there either to preserve and/or season them, or to safeguard them from potential enemies. The second option seems to be more plausible, since they were never retrieved (Slocombe, 2001). Waitore's objects (mostly consisting of damaged pieces of canoe), on the other hand, seem to have been discarded deliberately, as the majority of them were broken or worn out. The deposition (discard) occurred at the beginning of

the fifteenth century, making the site one of the earliest wet sites in New Zealand (Cassels, 1979). Agricultural tools as well as paddles were also deliberately abandoned near two fairly highly populated lakes, namely Harowhenua (Adkin, 1948) and Mangakaware (Bellwood, 1978). In these two cases though, the artefacts were deposited with the intention of being retrieved later.

Settlements

One of the major features of wetland occupation in ancient *Aotearoa*, and in particular the North Island is the *pa*, a typical 'fortified' Maori wetland village built on naturally or artificially elevated ground within swampy areas (see also Ch. 4, Box 4.5, 'The Maori *Pa*'). Some swamps or lakes have more than one *pa*. For instance, Lake Mangakaware, a peaty lake in the Waikato region, has yielded three *pa*, occupied in the sixteenth and seventeenth centuries, whereas Lake Harowhenua had six such island 'fortifications'. One of the best studied *pa* is, without a doubt, the seventeenth-century wetland village of Kohika located in the Bay of Plenty (Irwin, 2004*b*, 2005). The settlement was occupied for about two generations and abandoned after a flood. The area was quite volatile (e.g. flooding and occasional volcanic eruptions), but its advantages (e.g. food resources and water communication) made people reluctant to leave. The village consisted of a series of houses (*whare*), a carved house (*whare whakairo*), a few storage houses (*pataka*), and other minor elevated structures, all of them protected by a wooden palisade (see Ch. 4, under 'Houses in Wetland Contexts', and Box 4.5, 'The Maori *Pa*'). Another important settlement is the heavily protected riverside village of Oruarangi. Although it was still occupied at the time of Captain James Cook in 1769, the village was already thriving in the sixteenth century, and it was indeed then that it started to be enlarged, reaching an area of about 20,000 sq metres by the 1800s. The settlement was located in a very strategic location, and controlled the access to the hinterland and to the various trade networks in the region (Furey, 1996; Phillips, 2000). Oruarangi is one of the most important sites in terms of Maori material culture, in fact, it yielded one of the richest and most diverse collections of artefacts belonging to the classic phase of the Maori culture (Golson, 1959).

NORTH AMERICA
(see Maps 5 and 5A–D)

Although wet and/or wetland sites do not constitute a large part of the total archaeological research in North America, they play a crucial part in general archaeological thought. Both Canada and the United States have been yielding important waterlogged material, which has helped archaeologists

shed light on the significant relationship between Native Americans (or First Nations people in Canada) and their environment. As discussed in Chapter 1, a waterlogged site does not always correspond to a wetland site, and this is clearly seen in quite a few sites on the continent's Northwest Coast (e.g. Ozette). However, whether or not closely linked to wetland environments, thanks to the outstanding preservation of organic material, they may retain crucial clues as to how (and if) past cultural groups dealt with and exploited the wetlands. Such evidence may also come from unexpected places such as caves, as the examples from the Great Basin area show. Although wet/wetland sites are found in various areas of North America, there are nevertheless regions that have yielded a higher number of sites; for instance Florida and the Northwest Coast. Aesthetically pleasing archaeological evidence (e.g. the artefacts from Key Marco and Ozette and basketry from the Northwest Coast) combined with fauna and flora remains have contributed to a better understanding of the rich and fascinating cultural heritage of the North American continent.

Canada

Wetlands in Canada (see Maps 5A and 5C) cover about 14 per cent of the country's land mass, and although not equally distributed, they are a fairly common feature of the landscape in all regions. People–wetland interaction has always played a crucial role in Canada's cultural heritage, since the first human colonization of North America after the Last Glacial Maximum. Wet and/or wetland sites (see Ch. 1 for terminology) are found in various parts of the country, though the majority are located on the coastal area of British Columbia.

People's interaction with wetland ecosystems is usually reflected in the archaeological record. However, due to the fact that most of the pre-contact material culture was made of perishable organic material, poor preservation may compromise the survival of artefacts, resulting in incomplete archaeological evidence, such as, for instance, the total absence of pre-European First Nations watercraft remains in Canada. There are, nevertheless, a number of wet/wetland sites that, thanks to their rich archaeological assemblages, have been fully integrated into the country's mainstream archaeological rationale. One of the most prolific areas in terms of wet site archaeological evidence is the coast of British Columbia, with a special emphasis placed upon the Coast Salish regions, including the Fraser River Delta. Although the oldest site in a wetland (coastal) context—Kilgii Gwaai, *c.*9450 BP (Fedje et al., 2005)—is located on a remote island further north, it is in the Salish Coast regions that waterlogged sites have contributed to reshaping part of Canada's Northwest Coast cultural evolution. In fact, it was thanks to well-preserved material

culture (especially basketry) of sites such as Glenrose Cannery (4300 cal BP, the oldest in the Salish Coast area—St Mungo/Locarno Beach phases), Mosqueam Northeast (Locarno Beach phase), Water Hazard (Marpole phase), and Little Qualicum River (Gulf of Georgia phase) (see Table 2.3 for the absolute chronology of the various cultural phases) (Bernick, 1983, 1998, 2001; Foster and Croes, 2004) that archaeologists have been able to prove (or disprove) cultural continuity amongst the various Northwest Coast cultural groups. A surprising result was the identification of cultural dislocation (rather than continuity) with an amazing degree of sophistication during the Marpole phase (Bernick, 1998: 153). Although not part of the Salish Coast region, two other sites with important basketry remains are those of Lachane (Marpole phase) and Axeti (Gulf of Georgia phase), both located along the seaboard of Coast Mountains (Croes, 1992, 1997; Foster and Croes, 2004).

Three of the above-mentioned sites (Glenrose Cannery, Mosqueam Northeast, and Water Hazard) have provided further information concerning palaeo-economy, subsistence, and technology. The variety of fish-traps, weirs, and other fishing gear have shown that, while the exploitation of riverine resources (species of fish) remained the same for more than 2500 years (between 4600 and 2000 years ago), the primary procurement methods changed significantly; for instance, from simple traps used at Glenrose Cannery (4300 years ago), to more complex gill nets at Mosqueam Northeast (3000 years ago) (Stevenson, 1998). Because of the dynamic character of riverine environments, wet sites found in such contexts are sometimes difficult to interpret, as is the case of Scowlitz located on the confluence of the Harrison and Fraser rivers. A careful examination of the artefacts and their startigraphic context has confirmed that the objects are older than the soil matrix in which they were found, and they were probably transported there by the river from other locations (Bernick, 2007: 129).

Although more rarely, fish weirs are also found in regions other than the British Columbia coast, and in non-estuary environments. One of the best examples is the Atherley Narrows weir (southern Ontario), consisting of a series of stakes driven into the bottom of a relatively deep channel with fast-flowing waters. The structures were placed diagonally across the channel, and according to Johnston and Cassavoy (1978), the stakes were over 2 metres high, indicating a fairly constant water level since the weir was constructed (*c*.4400 BP). Subsequent studies and dating of the weir structures have revealed further reuse of the site around 3000 and 500 years ago (Ringer, 2006).

The most famous wetland site in Canada, and also the oldest evidence of European settlements in North America, is L'Anse aux Meadows, situated on the northern part of Newfoundland Island (Ingstad, 1977). The site consists of a Norse settlement established around AD 1000. It is interesting to notice that despite the solidly constructed turf houses (with wooden frames), metalworking (iron) facilities and various other workshops, the Norse colony stayed for

only a very short period of time (B. L. Wallace, 1991, 2000). The area of the settlement had been used by local First Nations groups as a seal-hunting camp before the arrival of the Norse, and they continued to do so after the Norse left. The location of the settlement highlights the importance of the close interaction that Norse people had with the surrounding marshy areas. In fact, not only were the marshes exploited as food procurement (hunting and gathering), but also as a source of turf, used to cover the walls and roofs of the houses (Davis et al., 1988).

A lot of wet/wetland sites in Canada are from riverine (including delta and estuary) environments, therefore in a clear *in situ* wetland context. A large number of sites are, however, stray finds, with little or no stratigraphic significance. The material they are made of though, makes them no less important, as they have the capacity of identifying cultural change (or stability) through time (see above). Also areas, rather than single sites, have contributed to improve our knowledge of how First Nations people interacted with the wetlands. One good example is the study of the Vermilion Lake region in Banff National Park, Alberta, where wet environments have been a fully integrated part of people's socio-economic life and played a crucial role for over 10,000 years (Langemann and Dempsey, 1993). Unfortunately, the vast majority of Canadian wetlands (swamps, marshlands, and lacustrine areas) have not, as yet, been investigated. But, since ethnographic studies (McMillan and St Claire, 1982; McMillan and Yellowhorn, 2004) show an active people–wetlands relationship, there is a strong possibility that present wetland ecosystems still retain rich evidence of past human occupation and exploitation.

United States

Past interaction of people with wetlands in the present-day territory of the United States (see Maps 5A–D) follows a specifically interwoven relationship between space and time. As different wetland ecosystems developed from the end of the Last Glacial Maximum onwards, they also shaped the various social groups who lived within and between them. The vast latitudinal and longitudinal extension of the country, as well as its diverse topography contributed to form (and develop) particular niches where wetland environments prevailed over other conditions. People's interaction with the wetlands was, at times, a widespread phenomenon. There are areas that have retained archaeological evidence of this long-lasting relationship better than others; for instance, Florida, the Eastern Woodlands (including the Mississippi River drainage system) and the Northeast Coast (eastern United States), and the Great Basin and the Northwest Coast (western United States). In general terms, the United States' past can be divided into four main chronological periods: Paleo-Indian

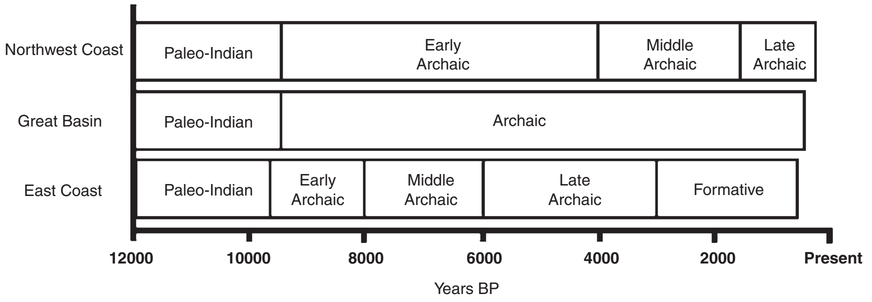


Fig. 2.6. Approximate chronological division of the US Northwest Coast, Great Basin, and East Coast prehistory. (*Graphic*: F. Menotti. Data source: Ames and Maschner, 1999; Matson and Coupland, 1995; Jennings, 1989; Fagan, 1991)

Archaic, Formative, and Historical. This division varies from place to place, with some differences between the West and East Coasts (see Fig. 2.6). Needless to say, the above-mentioned phases are further divided into sub-chronologies according to local archaeological groups/cultures. The two most fruitful periods in terms of waterlogged archaeological evidence are the Archaic and the Formative.

Although not strictly having waterlogged materials, there are a number of sites within both the Eastern Woodlands and the Great Basin that retain crucial information concerning socio-economic organization and resource management strategies of prehistoric communities (especially in the Archaic period) and their relation to the wetlands. For instance, the various sites found at Stillwater Marsh (Nevada) have contributed to prove that the mobility of local groups depended upon the varying productivity of the wetlands. As the marsh productivity (linked to other ecological settings as well) increased, the mobility of people decreased (R. Kelly, 1995, 2001). This conclusion is supported by a number of house-pit depressions located near the water, along with additional, different structures that might have had special functions rather than being simply dwellings. House-pit settlements near or within marshland environments seem to have been a consistent feature throughout the Great Basin in the Late Archaic period, as they are also found in other locations such as Diamond Swamp, Malheur Lake, Nightfire Island, and Lake Albert-Chewaucan Marsh, whose high number of structures might have also been linked to the wapato (*Sagittaria latifolia*) exploitation (Musil, 1995; Oetting, 1989). The Great Basin was a place with a rich wetland ecosystem, which continuously changed over time, according to individual development and the influence of external neighbouring regions. A similar situation was present at Robin Swamp in north-western Connecticut (north-eastern United States). The high number of occupations and their material culture are associated with what Nicholas (2007: 247) refers to as wetland mosaic,

consisting of swamps, marshes, and riverine environments particularly pronounced during the Paleo-Indian and Early Archaic periods. Wetland mosaics seem to lose their ecologically distinct significance from the eighth millennium cal BP onwards, as riverine and lacustrine systems become more attractive. Interestingly enough, people's relationship to Robbins Swamp can be correlated with the various phases of the wetland developments. As is shown by the ceramic-period occupations, despite these changes the swamp was never abandoned; its function simply changed from core to secondary use, while still being defined by and linked to other emerging core environments (Nicholas, 1988, 1992, 1998).

The large variety of plants and animals (aquatic and terrestrial) found in wetland ecosystems has always influenced people's subsistence and economy, to the extent that in some cases direct or indirect management might even have been taking place. Some plants were exploited intensively, not only as food but also as building materials, for instance the cattail (*Typha latifolia*) was used to make baskets, sandals, and mats. Other herbaceous perennials, such as the wapato, were (and still are) important sources of carbohydrates along the entire Northwest Coast of the United States and western Canada. Aquatic fauna is also a recurrent feature in the wetland settlement archaeological assemblages. Particular attention has been given to waterfowl, which seem to have played an important part in the wetland people's diet. Evidence shows not only constant patterns of waterfowl hunting, but also shifts in game preferences, as was the case at Nightfire Island, where coot (*Fulica americana*) were eventually replaced by scaup (*Aythya* spp.) about a thousand years later (Sampson, 1985). Whether the shift was due to a simple change in diet preference, overexploitation, or a more complex environmentally related adjustment of aquatic bird flyways is yet to be determined.

Evidence of people–wetland interaction does not only come from wet environments, but also from unexpected places located in drier areas, such as caves. Four of the best examples are Danger Cave (Utah), Hidden Cave, Lovelock Cave, and Spirit Cave in Nevada (Elston, 1986; Madsen, 1982). Danger Cave was used as a dwelling, and shows a remarkable 10,000-year-long 'continuous' occupation (12,000–10,000 cal BP), with evidence of shifting basketry techniques from twining to coiling (Jennings, 1989), whereas at Hidden Cave the use of cattail is evident in both dietary (coprolite) content and the use of artefact material such as sandals and basketry (Goodman, 1985). The same can be said about Lovelock Cave, where remarkable evidence of Early and Middle Archaic people's interaction with the nearby Carson and Humboldt Sinks of the Lahontan Basin was found. The lifelike duck decoys made of tule reed, as well as water plant and waterfowl remains found in the cave, are but a few examples of the close relationships people had with wetland environments of the area (Heizer and Napton, 1970). Spirit Cave, on the other hand, provides us with invaluable evidence of *c.*9500-year-old material culture

(including rabbit-skin blankets, tule mats, and leather moccasins) used in a funerary context (E. J. Dixon, 1999). Funerary practices in wetland contexts are also found near swamps (e.g. the Paleoindian cemetery of Sloan, Arkansas) (Delcourt et al., 1997), and even in the water, as in Windover, Florida (see below).

An area of the United States where wetland resources contributed to its continuous occupation, showing a remarkable increase in intensification and social organization from the Archaic to the Formative period, is the Mississippi River drainage system. Although the majority of mounds and/or earthworks are associated with the Hopewell and Mississippian Cultures, a few were constructed between the Middle and Late Archaic periods (*c.*6500–3300 cal BP) (Hamilton, 1999). Two of the best examples of mound construction within a wetland context are Watson Brake (from 5400 cal BP) and Poverty Point (*c.*4200–2700 cal BP), the latter displaying a U-shaped series of concentric ridges forming a central plaza with mound. Although not as yet proved, the habitations are supposed to have been located along the ridges of the entire complex (Fagan, 2000; Manley, 1993). These Middle and Late Archaic earthworks are significant, as they could mean either an early beginning (as previously thought) of social inequality, or complex social organization amongst egalitarian societies (Saunders et al., 1997).

The majority of proper waterlogged sites in the United States are located in Florida. There are, however, quite a few wet sites (not necessarily formed within a wetland context, but waterlogged subsequently) on the Northwest Coast, retaining remarkably well-preserved evidence of settlements (with dwellings), organic artefacts (in particular basketry), and fishing structures (weirs, fish-traps, etc.) (see below).

Northwest Coast

Along with Florida, the Northwest Coast of North America (see Maps 5A and 5B) is one of the most prolific places in terms of waterlogged sites in the United States. Although typical peatbog sites are also found sometimes (see e.g. the Manis Mastodon site (Gustafson et al., 1979)), due to the particular geomorphologic and hydrological composition of the area the vast majority of waterlogged sites are 'aquifer wet sites' (as they are called in this region), whereby low-oxygenated waters run through the sites, keeping them constantly water-saturated. Wet archaeological sites reflecting this characteristic are found in riverine estuaries (including areas of tidal flats), cove areas, in the proximity of creeks or springs, and along river channels (Croes, 1976). Research on wet coastal archaeological sites on the Northwest Coast started in the 1950s with shell midden explorations. Waterlogged organic material artefacts found amongst them triggered the interest of archaeologists and, following the discovery of a few wooden bowls along the eroded banks

of the Snoqualmie River, one of the very first wet-site archaeological excavations was carried out at Biederbost (east of Seattle, Washington), in the early 1960s (Nordquist, 1976). And it was during the 1960s that the foundations for the development of wetland archaeology were established. One of the best-known sites is without a doubt the Ozette Village, at Cape Alava, on the northwest tip of Washington State (Daugherty and Friedman, 1983; Kirk and Daugherty, 2007). The site was initially excavated as a shell midden, and it was not until the winter of 1969–70 that a severe storm exposed remarkably well preserved material belonging to a series of occupations, which had been buried by a number of mudslides. The first settlement dates to *c.*AD 1250. Destroyed by a large mudslide, the area was occupied again around AD 1440. About 200 years later this second settlement was also buried by a mudslide. Two more occupations followed (one of them flattened by yet another mudslide), and the last one continued until recent times. The most amazing finds of the various excavations at Ozette come from Unit V (the second occupation, *c.*AD 1440). Here, on top of an incredibly large number of artefacts, the remains of eight houses have also been found (Coles and Coles, 1996; Daugherty and Friedman, 1983; Kirk and Daugherty, 2007; Samuels, 1983). This Pompeii-like site remains at present unique, but considering the frequent mudslide activity on the entire Northwest Coast, more of such sites might await discovery (Croes, pers. comm. 2010).

Ozette is by no means the only important wet site on the Northwest Coast. There are a number of well-researched sites which, thanks to their remarkable archaeological assemblages (in particular basketry), have contributed to reshaping the entire Northwest Coast pre- and post-European cultural evolution. In fact, the outstanding basketry remains found at Hoko River (Croes, 1995, 1999) and Qwu?gwes (Croes et al., 2005, 2007), as well as those of a number of other United States and Canadian wet sites (e.g. Little Qualicum River, Musqueam NE, Glenrose, Pitt Polder, Water Hazard, Fishtown, and Conway) within the Strait of Juan de Fuca, Puget Sound, and the Gulf of Georgia, have begun to question the depth of cultural continuity amongst the various chronological phases, from the Early North Coast (*c.*9000–4000 cal BP) to the Recent (*c.*500 cal BP) (see Table 2.3).

Cladistic analyses show that cladograms derived from stone, bone-antler, and shell artefacts differ from those resulting from the basketry data, suggesting different transmission of information regarding the two sets of data. While ideas linked to objects made of stone, bone-antler and shell were more widely shared, those associated with basketry played an important role in ethnic identity (Croes et al., 2005: 141). This is also proved by contemporary First Nations weavers in the Pacific Northwest, where basketry traditions are still closely guarded and taught only to specific members of the family, within restricted ethnic groups. Recent studies (Croes, 1995, 2003; Croes et al., 2005; Foster and Croes, 2004) have also contributed to shed light on the ongoing

Table 2.3 Chronology of the Northwest Coast (Strait of Juan de Fuca, Puget Sound, and the Gulf of Georgia) cultural phases (Source: Croes et al., 2009: 143)

Phase	Date (cal BP)
Recent	500 cal BP—Present
Gulf of Georgia	1500–500 cal BP
Marpole	2500–1500 cal BP
Locarno Beach	3000–2500 cal BP
Early St Mungo	4000–3000 cal BP
Early North Coast	9000–4000 cal BP

macro-scale cultural evolution debate linked to ethnogenesis and phylogenesis hypotheses (Durham, 1992; J. H. Moore, 1994, 2001). The former hypothesis seems to be more suitable for stone, bone, antler, and shell artefacts, whereas the latter better fits basketry, since movement of ideas and trade related to it is more restricted and guarded.

Another important waterlogged site is that of Sunken Village (Portland, Oregon). The site (*c.*700–200 cal BP), consisting of 114 acorn-leaching pits, is crucial for our understanding of acorn processing and consumption, not only at a regional level (Northwest Coast), but also on a cross-continental scale, as comparative studies with similar sites in Japan have proved (Croes et al., 2009).

Two of the most common features in coastal (especially estuary) and riverine waterlogged sites in North America's Northwest Coast (including British Columbia—see 'Canada' above) are fish-traps and weirs. Their high number strongly contrasts with the almost total absence of this kind of archaeological evidence on the East Coast, with the only exception being the series of weirs found in the Boston Back Bay (Massachusetts), dating from 5300 to 3700 cal BP (Décima and Dincauze, 1998). Although recent fish-traps have been described in a range of ethnographic studies, it was only in the 1970s that systematic archaeological excavations began (Moss and Erlandson, 1998). One of the best-researched areas of the United States' Northwest Coast is the coast of Oregon, where all major river estuaries (Coquille, Coos, Siuslaw, Yaquina, Netarts, and Nehalem) have yielded fish-traps and/or weirs. Of particular interest are the sites of Ahnkuti (*c.*2200–300 BP), which has produced the longest stratified sequence (almost 2000 years) of fish weirs in Oregon, and Osprey (900–600 BP). The latter has not only yielded remarkable evidence of lattice panels, but has also shed light on the change of weir locations, according to landscape dynamics, caused by sea-level variations (Byram, 1998; Ivy and Byram, 2001). Weirs and fish-traps are also found in the southernmost part of Alaska. One of the best known is the Montana Creek fish-trap, an almost intact specimen dating to *c.*660–540 cal BP (Moss and Erlandson, 1998). In addition to the rarity of the artefact itself, the importance

of the site also lies in the fact that, as in the case of Osprey (see above), it has given scholars the opportunity to study geomorphologic processes, crucial for our understanding of site formation and settlement location within estuary environments (Betts, 1998; Chaney, 1998). An interesting comparative study of Oregon and Alaska fish weirs shows that the latter are much older than the former (Moss and Erlandson, 1998; Moss et al., 1990). Fish weirs come in many varieties, from estuarine (tidal weirs) to riverine. While riverine weirs are often large structures constructed across rivers to limit the fish passage (e.g. during spawning runs), estuary examples were erected in subsidiary channels, designed to work with the tide. Different lattice sizes found in archaeological (and ethnographic) records show that different fish species in relation to their size were caught (Byram, 1998). Fish-weir studies have confirmed that they are invaluable tools to better understand the importance of fishing activities in the Northwest Coast's past economies.

Wetland archaeological research on the Northwest Coast has gone through various phases of development since the 1960s. After a vigorous start with the Ozette and Hoko River projects in the 1970s, it experienced a low profile in the 1980s followed by a new revival in interest from the 1990s onwards, thanks to the discovery of a number of fish-weir sites. A major step forwards however, occurred in the early 2000s, when the direct involvement of local Native Tribes revealed the full potential for understanding and explaining well-preserved waterlogged sites and artefacts, and promoting the preservation and protection of the Northwest Coast's rich cultural heritage (Croes, 2010; Foster and Croes, 2004).

Florida

Two of the earliest waterlogged (indeed underwater) sites in Florida (see Map 5D) are Little Salt Spring and Warm Mineral Spring. Both sites have evidence of human skeletal remains and animal bones of extinct species. Amongst a large number of animal and plant remains (dated between 9900 and 9600 BP), Little Salt Spring (a 60-metre-deep flooded sinkhole) yielded a remarkable find, consisting of a collapsed shell of an extinct giant tortoise, impaled with a pointed wooden stake ^{14}C dated to 12,030 BP (the shell was older, *c.*13,450 BP). The find was recovered at a depth of 26 metres. The site was abandoned *c.*8500 BP, when the water level of the cenote started to rise, and reoccupied about 2000 years later; it was during this latter period that people living around the area buried their dead in the moist peat near the water. It is estimated that about 1000 individuals were buried in the area, but only 35 have been recovered. The site was abandoned when the water level started to rise again *c.*5200 BP (Clausen et al., 1979). The site of Warm Mineral Spring dates to the same time as the first occupation of Little Salt Spring (*c.*10,000–9500 BP) and has similar plant and animal remains. The only difference is the

recovery of a female human skull, considered to be the oldest human remains in Florida (Clausen et al., 1975). A similar underwater site with comparable chronology to the above two is Page-Ladson. As in Little Salt Spring (first occupation), the site yielded a number of plant and animal remains but no human skeletal parts (Dunbar et al., 1988).

From *c.*8000 BP wetter conditions began in Florida and, interestingly enough, the best waterlogged archaeological evidence from that period (*c.*8000–5000 BP) comes from mortuary ponds. The best-known (and the oldest) is Windover (*c.*7400 BP), where the remains of 168 individuals (of which 91 retained well-preserved brain material) have been found. The bodies were placed in the water within 48 hours of death, and held to the bottom of the pond by a series of wooden stakes (see Fig. 4.32). Unfortunately, despite the immaculate preservation, DNA seems to have been damaged (Doran, 2001*a*: 13) (see Ch. 4, and also Chs. 5 and 6 for preservation and DNA analyses). Grave goods and textile materials (used to wrap the bodies) have also been found. Archaeological analyses have identified 63 types of plant (34 edible) including a bottle gourd (*Lagenaria siceraria*) dating to 7290 ±120 BP (Doran, 2001*a*, *b*, 2002; Doran and Dickel, 1988).

Republic Groves was discovered in 1968, when a swampy area was drained to gain agricultural land. The site yielded human bones (37 individuals), flora and fauna remains, and a series of wooden stakes made of pine, probably associated with the burials (as in Windover). Utilitarian and ornamental objects (beads, awls, knives, etc.) made of bone, and a few pieces of cordage were also recovered. Particular stone beads originated from outside the region, were evidence of long-distance contacts among aboriginal populations. Spearheads from the Middle Archaic period in Florida, as well as ^{14}C dates, place the age of the site at *c.*6000 BP (Saunders, 1972). A similar site (although slightly older—*c.*6500 BP) is that of Bay West. Here we have the same number of human individuals (37) as in Republic Groves, but the site did not yield any human brain material (Purdy, 1991).

Waterlogged sites of the Late Archaic/Early Ceramic all belong to the so-called Mount Tylor period, when freshwater shells were first exploited in Florida. Tick Island, for instance, is the best example, but was almost completely destroyed by modern commercial shell mining in the 1950s. In addition to the large number of animal bones and artefacts made of shell and stone, the archaeological assemblage included well-preserved wooden figurines, such as the famous turkey buzzard clutched by the talons of a large raptorial bird, and pottery fragments, believed to be some of the oldest in North America (Purdy, 1992). A similar site is that of Grove Orange Midden on Lake Monroe, which has also yielded a hefty variety of objects, ranging from bone tools to wooden artefacts, including pottery sherds and ‘boiling balls’ (spheres of fired clay used to heat water—see also the *fulachta fiadh*,

Ireland). The site dated to between 6000 and 4000 BP, but it is interesting to see that it can be compared with the occupation of Hontoon Island (see below) nearly 5000 years later. The archaeological assemblage is very similar, and it is assumed that the way of life did not change for more than five millennia. The major differences between the two sites are the decorative patterns on pottery, the temper used, and the vessel shapes (Purdy, 1991, 2001).

The Formative period (*c.*3000 BP to AD 1500) includes sites that have a strong economy based on aquatic resources, frequent wood carving, and traces of social hierarchy, but little evidence of plant cultivation. Known for its remarkable wooden masks, the most famous site of this period is probably Key Marco (AD 650–900). The site has yielded a large number of animal bones from both marine and terrestrial fauna, but no human remains have ever been found (Coles and Coles, 1996; Gilliland, 1989). Similar artefacts and wood carvings have also been found at Belle Glade on the southern shore of Lake Okeechobee. Shell, bone, and wood industries were well developed, but ceramics were not particularly sophisticated. The skulls of seventeen male and twenty female individuals were recovered, but it is believed that the number of burials is much higher (Purdy, 1991). West of Lake Okeechobee, along Fisheating Creek lies the site of Fort Center. It shows four periods of occupation, from 2400 to 250 BP. Amongst the four phases, the second (1750–1150 BP) is particularly interesting because of its mortuary area, which consisted of two mounds and an artificial pond with a wooden platform, on which bundled burials were placed (see also Ch. 4, under 'Mortuary Practices'). After burning, the platform (with its numerous wooden carvings—69 have been recovered) and about 300 bundled corpses fell into the water and became waterlogged, preserving them until they were found and excavated in the 1960s–1970s (Hale, 1984; Sears, 1982). Midway along the St Johns River lies Hontoon Island. As is the case with Tick Island, the site was a garbage midden with hundreds of thousands of animal bones, shell refuse, and botanical remains. Its water-saturated depositional sequence offers an invaluable insight in a more than 1500-year-long occupation, which continued even after the first contact with the Europeans. The site shows a remarkable continuity in subsistence strategies until the post-contact period, when plant cultivation was first introduced. Unlike at some of the above-mentioned sites, only scattered fragments of human bones were recovered from the excavated area (Purdy, 1987, 1991). A particularly interesting site is the Pineland Site Complex, which, along with Key Marco, are the only two coastal wetland sites in Florida. The site, occupied in various phases from AD 50 to AD 750 (Caloosahatchee cultural period I–V), has great potential for the study of preservation processes and site formation on coastal environments in relation to a rapid rise in the sea level. This has crucial implications for coastal archaeological sites in terms of discovery, management, and conservation, as well as for the study of environmental issues such as palaeoclimatic variations (Marquardt and Walker, 2001).

An artefact that is particularly abundant in Florida is the canoe. Up until the year 2000, about two hundred canoes had been recorded throughout the state, spanning from 5000 years ago to the nineteenth century. As a result of prolonged drought, the level of Newnans Lake dropped considerably in the spring of 2000, exposing more than a hundred canoes, dating from *c.*5000 to 500 cal BP. All the canoes were found along a 2.5-km stretch of exposed northern shoreline. There have been a few hypotheses as to why so many canoes were concentrated in such a relatively small area. Although still open to discussion, the three most plausible ones are: abandonment (e.g. a cemetery-like effect), drifting (as a result of wind or storms), and a possible manufacturing area (Ruhl and Purdy, 2005). Following this important discovery and a few more in recent years, the number of known canoes in Florida has risen to over 350 (Barbara Purdy, pers. comm. 2010). It is interesting to notice how the concentration of canoes varies considerably. For instance, the majority are located in the north-eastern part of the country, whereas there are only a very few canoes in the south, especially between Lake Okeechobee and the Gulf of Mexico (Newsom and Purdy, 1990; Purdy, 1992).

Although, unlike cave sites (e.g. Danger Cave and Spirit Cave), wetland sites in Florida date mainly to single periods, they offer invaluable glimpses into the North American people's past. It has only been possible to identify the richness of different cultural groups by means of the large amount of organic material recovered; if this had not been preserved, the archaeological record would have reflected an incorrect image of such cultural groups and their way of life.

As in most parts of the globe, North American wet/wetland sites tend to reflect single time periods, which, because their scattered distribution, are difficult to arrange in a diachronic way. Their advantage though, is the vast variety of evidence ranging from direct (waterlogged wetland sites—Florida) to indirect (water-saturated terrestrial sites—Northwest Coast), or even well-preserved material culture extraneous to wet contexts, but showing an evident link to wetland environments (caves of the Great Basin). It is only by joining them that a full picture of the continuous relationship of people with wetlands through time and space emerges.

CENTRAL AND SOUTH AMERICA
(see Maps 6 and 6A–C)

Archaeological evidence of waterlogged organic artefacts, wooden structures, and/or habitations is not particularly abundant in Central and South America. However, former and present wetland areas still retain rich proof of people–wetlands interaction, especially concerning agricultural activity. Although manipulation of wetland landscapes for agricultural purposes was not the

only interaction people had with wet environments (hunting, fishing, and gathering were also common activities), this kind of exploitation was certainly the most widespread. Agricultural activity varied substantially according to the type of wetland and the climate of the area. For instance, methods of cultivation and primary productivity of lowland estuary in riparian systems are considerably different from those in the highlands located within water basins or in humid areas with fluctuating water-tables.

Identifying ancient field systems in Central and South America is not an easy task. Anthropogenic sediments located within areas subject to flooding may, in fact, be buried in fairly deep sediments. However, a number of field systems are still visible, and in these cases aerial and satellite imagery can be of great help in discovering and mapping them. Although wetland agriculture may take different forms, three types prevailed and have been adopted throughout the Central and South American continent: drained, recessional, and raised field agriculture.

The drained type consisted of manipulating the landscape with ditches and canals around the fields in order to manage the water level for crop growth and transport. Because of the large number of rivers and flood plains, recessional agriculture is thought to be one of the most widespread agricultural adoptions in Central and South America. Basic recessional systems consist of simply planting crops on higher ground (e.g. levees) within receding waters, before the beginning of the dry season (Siemens, 1998). The infrastructure needed is minimal, but drainage control may be applied in some cases. Although regarded as 'risk aversion' cultivation (to ensure extra crops for difficult periods), this type of agriculture could be highly productive in some regions (Whitmore and Turner II, 2001). Finally, raised fields are usually created by dredging the ditches and canals around fields and depositing the soil on top of the fields. How high they become depends upon the level of organic matter decomposition and how the water-table is managed (e.g. by construction dams, sluices, and canals) (Beach et al., 2009).

Typical wetland landscapes that may encompass all the above-mentioned types of cultivation are the Bajos, generally formed in karst depressions. Bajos, particularly common in Mesoamerica, are well above the perennial water-table, but they have high hydrological variability. As a result, water availability (and water-table) varies considerably from season to season, allowing all three types of agriculture (drained and raised field and recessional cultivation) to be adopted (Dunning et al., 2002).

Mesoamerica

Agricultural fields in wetland ecosystems are found throughout Mesoamerica (see Map 6A) from Mexico to Honduras, and from coastal lowlands to inland

highland areas. For instance, rectilinear canals and fields dating from the Olmec time and later cultures have been identified along the coastal plains of Veracruz and Tabasco, with intensive maize cultivation starting around AD 500 during the Totonac period (Siemens et al., 1988). In the Maya Highlands wetland agriculture was not well developed. However, indigenous raised beds are found around Lake Atitlan near Panajachel (Guatemala), and evidence of complex hydraulic management in wet environments (dating from the Middle to Late Preclassic—see Table 2.4) has been discovered at Kaminaljuyu on Lake Miraflores (near Guatemala City) (Mathewson 1984; Valdés 1998).

The majority of wetland agricultural field systems is found in the Maya Lowlands, with some of the best researched areas being the plain of Campeche, the Bajo Marocoy (Mexico), and at the Birds of Paradise and Chan Cahal on the floodplain of the Rio Bravo (Belize) (Beach et al., 2009, Gliessman et al., 1983, Pohl and Bloom, 1996, Pohl et al., 1996, Pope et al., 1996). The long chronology (from the Maya Archaic period to the Postclassic) of these agricultural field systems has allowed the development of a few models of field formation, which describe the various adaptations to the fluctuating water-table in conjunction with climate and environmental change (Beach et al., 2009, Pohl et al., 1996). For instance, the flooding at Chan Cahal during the Preclassic period may have triggered wetland reclamation, as much as the Late Classic Maya Drought may have prompted a closer contact with the wetlands (Adams et al., 2004).

An area with interesting features of wetland adaptation and agricultural field development is the Yalahan region in the north-eastern part of the Yucatán Peninsula. Here a large number of rock alignments (over 70), reaching 700 metres in length, have been located near the site of Makabil. The various rock alignments date from the Late Preclassic to the Early Classic (*c.*100 BC–AD 400), and they were possibly used as water and soil control structures for growing crops. The complex is one of the most significant areas of Maya wetland management in the northern Yucatán Peninsula (Fedick, 1996, 1998; Fedick and Morrison, 2004). Remarkable evidence of wetland agricultural field systems also comes from the Valley of Mexico, where raised fields known as *chinampas* were built around the former Lake Texcoco

Table 2.4 Chronology of Mesoamerica (Source: Carmack et al., 1996; Culbert, 1983; Morley and Brainerd, 1983)

Phase	Date
Paleo-Indian	12,000–7000 cal BC
Archaic	7000–2100 cal BC
Preclassic	2100 cal BC–AD 250
Classic	AD 250–900
Postclassic	AD 900–1520

(and more precisely around the Mexica-Aztec city of Tenochititlán), whose area is now occupied by modern Mexico City (Frederick, 2007). Little is known about the chronology of these field systems, but scholars argue that they started to develop well before the Aztecs, as early as 3400 years ago. Most of the *chinampas* are, however, dated to the Early Aztec or Middle Postclassic (AD 1150–1350). Wetland agricultural systems are also found around Teotihuacan, before the development of the city (*c.*2600 BP) (Sluyter, 1994). The size of the *chinampas* varied significantly, ranging from 3 metres wide to 100 metres long. Their surface was stabilized with layered nets of aquatic vegetation, and organic sediments dredged from the surrounding ditches was then placed on top of the fields to fertilize the soil. The hydrology varied from seasonally inundated areas to permanent shallow waters, which were sometimes regulated by a series of dykes (Denevan, 1970, 2002; Parsons and Denevan, 1989). *Chinampas* farmers adopted crop rotation, with the main cultivated plants being maize, squash, beans, chillies, and amaranth (M. E. Smith, 2003).

Although not as abundant as with the ancient agricultural field systems, archaeological evidence of people–wetlands interaction is also found in other wetland contexts. One of the best examples is the use of the cenotes as places for sacrificial offerings. The most famous and best-studied of such cenotes is the Cenote of Sacrifice in Chichén Itzá (Coggins, 2001) (see also Ch. 4, under 'Hoards, Offerings, and Depositions' and 'Anthropomorphic and Zoomorphic Wooden Figures').

As pointed out earlier, waterlogged remains of houses and other wooden structures in Mesoamerica are rare. One of the very few examples is the site of Los Buchillones (Cuba), where there are two houses (one circular and one rectangular). The houses, dating from the fifteenth to the seventeenth century AD, have been found in a lagoon-like coastal environment (Pendergast et al., 2001, 2002; Peros et al., 2006) (see also Ch. 4, under 'Houses in Wetland Contexts').

South America

A similar situation is found in South America (see Maps 6B and 6C), where, in contrast to the large number of wetland field systems still identifiable in both lowland and highland environments, waterlogged remains of wooden structures and habitations are extremely scarce. Interestingly enough, the only certain evidence of wetland dwellings is that of Monte Verde (Chile), which is also the oldest in the world (*c.*12,500 BP) (Dillehay, 1997) (see also Ch. 4, under 'Houses in Wetland Contexts').

Agricultural field systems are found in various parts of South America. Different forms of field mounds and canals, starting from 1600 BP, have been

researched on the Guianas Coastal Plain, located between the Orinoco and Amazon rivers (Rostain 2010). Rectangular and small-mounded fields, dating from 1550 to 1300 BP and 700 to 300 BP have been identified at the southern end of the Amazon Basin at Llanos de Mojos (northern Bolivia) (Walker, 2008), and examples of 3000-year-old wetland farming with three styles of ridged fields and ditches have been researched at San Jorge (Columbia) (Denevan, 2002). Six- to nine-hundred-year-old field systems have also been found in central Chile, and more precisely in the seasonally brackish deltas of Lake Budi and the Imperial River estuaries (Dillehay et al., 2007). Examples of people's adaptation to subtropical wetland environments are also found in the Merin Lagoon in south-eastern Uruguay, where hunter-gatherer groups of the Early Formative period (*c.*4000 BP) adopted small-scale horticulture, engaging in wetland cultivation of maize, beans, and squash. The method used was flood-recessional agriculture, planting the crops soon after the wet season, when transgressive waters start to recede (Iriarte et al., 2001).

Wetland cultivation in South America did not take place only in the lowlands, but also at high altitudes. Extensive raised fields are, for instance, found around Lake Titicaca in the Andean Highlands (Erickson, 1995, 2000; Erickson, 2006). The earliest raised fields in this area date back to between 3800 and 2900 BP, but the main expansions occurred from 2200 and 1400 BP, with the majority of fields being constructed between 1400 and 800 BP. Two basic forms of wetland fields are distinguished in the Lake Titicaca Basin: sunken gardens (*q'ochas*) and raised fields (*suka kollus* or *waru warus*) (Erickson, 2000). Raised fields are shaped in different geometrical forms, such as open checkerboards, combs, meanders, ladders, and lines. The size varied, but on average they were up to 3 metres high, 10 metres wide, and 100 metres long. The ancient fields and canals complex of Lake Titicaca (including Peru and Bolivia) is enormous, reaching *c.*120,000 hectares and possibly more at its maximum expansion (Erickson, 2000, 2006). Agricultural activity was not the only subsistence strategy in wetland environments: archaeological evidence also shows the importance of fishing, with remains of fish farming in the south-western part of the Amazon Basin (Erickson, 2001).

The Lake Titicaca Basin is not the only highland area where raised field cultivation is found. Wetland fields at altitude have also been located near Bogotá and Colombia in Colombia and at Cayambe and around Quito in Ecuador (Denevan, 2002).

As stressed earlier, Central and South America's ancient field systems are an invaluable source of information concerning cultural adaptations directly linked to environmental change. How climate influenced the environment, and how people responded and adapted to it, afford precious clues to understanding the development of past societies and how to face modern problems deriving from the incumbent threat of climate change, especially within delicate ecosystems such as wetlands (see also Ch. 9).

CONCLUSION

As highlighted throughout this chapter, people–wetlands interaction has been a worldwide phenomenon since the dawn of humanity. The reason why we may not find archaeological evidence related to wetland environments in specific areas is either because of lack of wetlands or poor preservation. It should, however, be pointed out that the absence of waterlogged remains does not necessarily mean an absence of people–wetlands interaction in the past. As is clearly shown by a number of sites (especially in Africa and the Middle East), dynamic environmental change has in many cases transformed wet ecosystems into dry lands, and water-saturated conditions may no longer be present. Careful palaeoenvironmental reconstructions can, however, reconnect those occupations to their former wetland origins.

The study of dynamic palaeoenvironments and a proper contextualization of former wetland occupations can also help archaeologists avoid biased assumptions on severe environmental change. For instance, contrary to what was previously thought, sea-level transgressions in the Mesolithic Baltic Sea regions and in the Russian far east during the transition from the Atlantic to the Subboreal period are now seen as positive rather than disadvantageous for coastal populations. Similarly, the Neolithization of Europe was not an unavoidable process to which Mesolithic groups had no choice but to succumb—choices were in fact made, and specific socio-economic situations purposely avoided or adopted. Prejudices against apparently inhospitable wetland ecosystems have also been reconsidered. The number of wooden trackways in northern Europe has shown that bogs and marshland areas were not penetrated marginally for sacred purposes, but were also crossed extensively for communication, trade, and other social reasons. Whatever the motivation might have been, the wetlands were never considered to be an insurmountable obstacle. Finally, despite the ubiquitous character of wetland exploitation all over the world, there are still activities that are endemic to very restricted areas. A typical example is the Early Holocene underwater cemeteries of Florida (e.g. Windover) in the United States. Such burials are not mirrored in any other part of the world.

The long, yet by no means exhaustive list of wetland occupations discussed in this chapter shows, once again, the importance of those ecosystems in people's everyday lives. Wetland areas were inhabited and/or exploited for various reasons, but regardless of what that purpose might have been, they have never been considered as isolated entities. In other words, wetlands were (and in some parts of the world still are) very much part of a wider socio-economic and geographical context, which cannot be fully understood if the wetlands themselves and their cultural heritage is excluded.

3

Living In and Between the Wetlands: Resource Potential and Adaptability

INTRODUCTION

Either by their own choice, or forced by natural phenomena, people are sometimes required to adapt to new environments. Behavioural and physical adjustments to environmental change are both germane in studying human adaptability. However, the most common forms of adjustment are behavioural, social, and cultural, as these forms require less commitment by the physical organism (Moran, 1990). The behaviour is therefore a form of regulatory response that can either serve to maintain a stable relationship to the environment, or facilitate adjustment to variability in that environment (clothing and shelter are the most common regulatory mechanisms). Because people adjust to environmental conditions in different ways, it is crucial to consider the place in which adaptation occurs from a holistic perspective. In other words, it is important to understand how various ecosystems within the environment are structured and functionally related (Gardner and Stern, 1996; Rappaport, 1971). For instance, low mean biological productivity may limit the population density that can be supported; as a result, activity must be reduced to minimize caloric expenditure, and all this can result in population loss through famine. In contrast, migratory behaviour, trade, and contact with other groups may provide the right matter and information expenditures to keep the demographic density at an acceptable level (Arbogast et al., 2006; Rappaport, 1977).

In order to avoid excessive environmental deterministic explanations, the chapter adopts a rather Boasian approach (Boas, 1963 [1911]) to assess how environmental change (including climate change) influences people, and the extent to which people respond to it by directly or indirectly affecting the environment itself. The delicate balance of people with the environment is sometimes irreversibly altered, resulting in inevitable subsistence and economic crises. It is therefore crucial to examine the human–environment interaction from both perspectives: environmental and sociocultural.

For example, the drastic impact that climatic change has on dynamic landscapes (e.g. Middle Bronze Age lake-level fluctuations in the Circum-Alpine region—see Box 3.2), may trigger sociocultural, political, and economic adjustments (e.g. Neolithic adjustments to subsistence crisis, resulting in tool technology changes in the Alps—see Box 3.1), which, themselves, are linked to physiological and social variables as well as being intricately interwoven with the environment.

The high biological productivity and resource potential of some wetland ecosystems has always attracted people. It is therefore crucial to understand how the quantity and quality of the resources in a wetland ecosystem are available to local groups, and how they depend upon the biological productivity that the wetland system itself can offer (Mitsch and Gosselink, 2000, 2007). The chapter explains how and why people choose specific types of wetland, and how different choices vary significantly through space and time.

With the help of population ecology studies, the chapter discusses an overview of various adaptation processes triggered or influenced by the natural environment (Kormondy and Brown, 1998). Physiological responses (especially the reversible ones) are germane in human adaptation, but it is indeed the flexibility of the sociocultural adjustments that determines success or failure in settling new environments, and/or coping with external (unexpected) stress factors. Migrations and displacement are considered in all their forms in the last part of the chapter (see 'Migration and Displacement', below); from demographic pressure to social push factors, intrinsic in the community's social structure. Archaeological evidence may be misleading sometimes as far as migration processes are concerned; what seems to have been caused by demographic pressure may have been the result of social factors deeply rooted in the community's social structure and beliefs.

Finally, the colonization of new environments requires knowledge about natural and cultural aspects of the foreign area. Acquiring knowledge about a particular new landscape is called: 'landscape learning process' and it is most likely to occur in situations of initial occupation, although, as explained in the final section of the chapter, particular landscape learning processes can take place in already occupied areas. Both cases have advantages and disadvantages, as different kinds of barrier (knowledge, population, and social) come into play, according to the various social and environmental contexts (see Rockman, 2003).

PEOPLE–HABITAT INTERACTION: THEORETICAL PERSPECTIVES

Three major Western intellectual currents have dominated the explanation of the interaction of people with nature: (*a*) the environmental deterministic

view, whereby nature has a determining influence on society; (*b*) human adaptation to the environment, with people prevailing over nature; and (*c*) the environment seen as a limiting factor to human possibilities. The latter is also interpreted as a bridging and/or compromising approach to the first two.

The environmental deterministic view, developed from Greek, Roman, and Arab theories that emphasize the influence of the environment (landscape, climate, etc.) over humans, argues that positive and negative human achievements are directly affected by the surrounding nature (Alavi, 1965; F. Thomas, 1925). The validity of the environmental deterministic approach was not questioned until the eighteenth century, when human progress started to be appreciated and the idea of human control over nature began. New insights into people's capability of adapting to nature were triggered by the development of the evolutionary theory, which also contributed to explaining diachronic changes and continuity. It was thanks to the influential works of Malthus, Lyell, and Darwin that the perception of human–environment interaction started to change radically; people have indeed the chance to prevail over nature! Nature was then seen as a limiting factor, which could be overcome if different variables within the population and related to the obstacle could be understood and explained. Initially pointed out by Malthus, this new approach was subsequently developed by Boas. Starting from an environmental determinist orientation, Boas soon realized that people's success over nature was to be found in the study of cultural difference, or cultural history of the various societies (Boas, 1896, 1963 [1911]). The Boasian clear orientation to the human side of the people–environment equation is seen as a sharp reaction to the deterministic view, and a return to more scientific and empirical explanations.

People–habitat studies have seen important developments since the 1950s. The cultural ecology approach of Steward (1955) aimed to identify the relationship between environmental resources, subsistence technology, and the means required to bring this technology to bear upon resources—in other words, the process of resource utilization. Steward's work led to the development of cultural ecology, which, as the term implies, uses an ecological approach to cultural studies (Netting, 1977; Steward, 1973). His comparative approach was soon criticized for not being able to yield a cause-and-effect relationship and for neglecting specific research focuses such as the influence of demographic make-up, human physiological adaptations, ritual, diseases, and political domination. As a reaction to these shortcomings, a new research approach known as ecological anthropology, or system ecology, developed (Vayda and Rappaport, 1976). The focus of this approach is placed upon the dynamic relation between the living and non-living entities of an ecological system. The need for a better understanding of how people perceive their environment and how their perceptions are organized led to the development

of a new approach: the ethnoecological approach, also termed 'ethnoscience' (Frake, 1962). It was believed that by adopting such an approach, the tendency of imposing an outsider's *a priori* structure upon the data could be avoided (Nazarea, 1999). This latter assumption was later harshly questioned and criticized. The 1980s and 1990s were characterized by the development of two more theoretical approaches, historical ecology and political ecology, which aimed to address the inadequacies of other previous research trends (Brosius, 1997; Crumley, 1994; Sheridan, 1988). Historical ecology in particular was preferred by archaeologists in the study of landscape units, in order to understand interactions between people, climate, and landscape (Crumley, 1994). A new trend of research by the name of 'human dimensions of global environmental change' has been developing since the 1990s. This consists of a multidisciplinary effort of environmental social scientists and biophysicists to gauge people's impact on the environment, in order to be able to face possible environmental variations (including climate change), in the future (Walker et al., 1999) (see also Ch. 6).

ECOSYSTEMIC RELATIONSHIPS: VARIABILITY AND RESPONSE

With the acceptance of the ecosystem concept (derived from biological ecology), which views all organisms as part of ecological systems and subject to the same physical laws, social and biological approaches have been fully integrated into the study of human adaptability to the surrounding environment. As a result, the interaction between two populations and also the environment is seen as mutualistic. This approach enables the application of a large body of data to explanatory models of human behaviour (Golley, 1992; Moran, 1990).

Although the entire biosphere could be seen as one single ecosystem, it is useful to distinguish between smaller and more homogeneous biogeographical regions, also called biomes. Species may vary between regions or areas, but types of flora and fauna across biomes will show similarities resulting from adaptation or adjustment of species to similar ecological conditions. For instance, both terrestrial and aquatic ecosystems show similarities in how they respond to environmental stress (Rapport and Whitford, 1999), although it has to be pointed out that some aquatic ecosystems are more prone to drastic stress than their terrestrial counterparts. The ecosystem functions thanks to three essential components: energy, matter, and information. The incoming energy is converted into biomass, which in turn sustains animals and humans. At the same time, while organic matter is converted into inorganic matter through chemical energy, information control changes in

the ecosystem structure and function, inducing overall adaptation to both internal and external conditions.

The Environmental Setting

Regardless of the various biomes (wetland or dryland), green plants are crucial biological organisms, which are able to convert solar energy into plant biomass. The growth and development of this biomass depends upon a number of factors ranging from temperature to soil nutrients and water. What becomes available to people, though, is the difference between the total energy assimilated by plants (gross primary production), and the respiration (process of energy transfer to keep the plants alive). Interestingly enough, the more complex the ecosystem, the greater the gross primary production, and the smaller the proportion that becomes available to people. Constraints present in the area (e.g. water availability, temperature, soil, etc.) do of course influence the ratio of production to productivity (Moran, 2000).

How people use and/or cultivate plants is closely linked to the soil, which itself can be managed and modified in order to increase its productivity. Soil composition is highly dynamic and may vary frequently and within short distances. Soil orders are closely associated with different ecosystems (Goldberg and Macphail, 2006); for instance mollisols are characteristic of temperate grasslands, whereas in wet areas one is more likely to find oxisols, rich in a high proportion of iron oxides (see e.g. bloomery iron from bog ore). It is therefore crucial, especially for farming populations, to be familiar with soil productivity and be able to locate fertile areas, especially within wetland environments where the availability of tillable land is restricted.

Wetland Bioproductivity and Biodiversity

In a wetland ecosystem, the quantity and quality of the resources available to people depend upon the biological productivity that the wetland system can offer. Wetland ecosystems are extremely variable: some are amongst the most bio-productive ecosystems in the world, others are the least. As briefly pointed out above, biological productivity is merely identified in terms of biodiversity, in other words, the amount of biomass generated by the ecosystem. Biomass productivity is usually divided into primary and secondary productivity, whereby the former is the amount of organic matter synthesized by organisms (mainly plants), whereas the latter is the amount processed by organisms from primary producers. As a result, primary productivity provides energy to support secondary producers, as well as other consumers higher up the food chain (Mitsch and Gosselink, 2000, 2007; M. Williams, 1990). Primary productivity in wetlands is linked to the amount of nutrients available to primary

producers, but it is also crucial how primary products are converted to be available to secondary producers. This process is closely connected with decomposition of organic materials before they are ready to be assimilated by primary producers. A reduced or accelerated decomposition may hinder or favour specific wetland environments, determining their resource potential. In general, permanently waterlogged areas with low oxygen content and low pH have low primary productivity, whereas periodically flooded places with oxidized terrains have higher primary productivity. For example, a rain-water-saturated (ombrotrophic) place, such as a blanket or raised bog, would have a low content in nutrients (oligotrophic) and therefore low primary productivity (Mitsch and Gosselink, 2007). On the other hand, minerogenic wetlands that have access to groundwater and floodwater, such as riverine systems (including estuaries), fens, and reed swamps, have higher primary productivity, thereby becoming more attractive to people.

Settling and Exploiting the Wetlands

The high biological productivity and resource potential of some wetland ecosystems have always attracted people in one way or another. Although this is sometimes clearly reflected by archaeological evidence, the equation 'high productivity = occupation' varies significantly through space and time. In the Humber wetlands in northern England we notice, for instance, a chronological decrease in interest in wetlands throughout prehistory: from a specialized exploitation of nutrient-rich wetlands during the Mesolithic, to a reduced interest in wetland resources, mirrored by an increase in agricultural activity in the Neolithic and Bronze Ages. As time elapsed, the relationship between wetland biological productivity and human exploitation decreased in importance, as is shown by the increased number of Roman settlements in the wetland areas of low biological productivity on the Humberhead Levels. By the seventeenth century, the Humber wetlands had become marginal, and, although some were still used for waterfowling, the majority was being drained to create more agricultural land. Their exploitation was then mainly driven by socio-economic and political factors (Van de Noort, 1998, 2004*a*; Van de Noort and Ellis, 2000).

A different picture is presented within the lake-dwelling tradition of the Circum-Alpine region, where less dynamic wetland ecosystems as well as a different economy shaped rather diverse patterns of exploitation. The lakes had initially been settled by communities with an already established agricultural economy. The selected tillable land near the lakes had little or nothing to do with the wet environment, as the plots of land were mainly located on gentle slopes in a totally dry environment (see Fig. 3.1) (Dieckmann et al., 1997; Maier and Vogt, 2001*a*; Menotti, 2004*b*). The dryland slopes near the lakes would of course be influenced by climatic variations (see below), but they

would not undergo drastic physical change (e.g. paludification, peat formation, etc.). Therefore, the occupation of the lacustrine areas was not only strictly linked to the wetland productivity (although people did take advantage of the rich wetland resources, such as fish, waterfowl, etc.), but also to the suitable location of dry tillable land for agriculture.

The wetlands were also penetrated, explored, and enculturated for non-profane activities, such as depositions, offerings, and sacrifices. Intense activity not necessarily linked to the high primary productivity of the wetlands, is, for instance, shown by the numerous wooden trackways in peatbogs (although some were related to subsistence—see Ch. 4), special seasonal habitations (e.g. Alvastra, Sweden), and even mortuary practices (e.g. the underwater cemetery of Windover, Florida), found in various parts of the world.

Population Ecology

Population ecology studies are crucial to understanding the various factors that are part of the structure and process of a given population, its interaction with other groups, and the effect that environmental variations may have on them. Populations respond to environmental change with physiological and behavioural adjustments, and in some cases even genetic transformations may occur. An important aspect of a population is its flexibility to face a potential stress (which could be social, environmental, or economic—internal or external—see below). Stability and flexibility are enhanced by intra/inter-population variability. A population can either increase, decrease, or remain stable, depending on the birth/death ratio, which is itself influenced by a myriad of factors (Willigan and Lynch, 1982). In an ideal situation a population grows exponentially, but this occurs only very seldom, as a number of sociocultural practices as well as a variety of external factors come into play to slow or stabilize the exponential expansion. Mortality and fertility rates are two important elements to gauge a population increase (Chamberlain, 2006). Of the two, the former is less complex and far more accurately determined, as death only happens once. Conversely, fertility measures are much more complex, for they depend upon a combination of intermediate variables dictated by a number of intrinsic (e.g. contraception, foetal mortality, age of marriage, frequency of sexual intercourse, etc.), as well as extrinsic (e.g. climate, food supply, wars, diseases, etc.) factors (Davis and Bernstam, 1990; Moran, 2000). Briefly, a demographic decline in a given culture group may be the result of an initial shortage of food triggered by climatic variations that forced the population to adopt drastic contraceptive methods (even infanticide) to reduce the number of people in the community so as not to starve. Another measure to cope with demographic decline due to socio-economic factors is migration. Either a move to a new place or absorption of incomers

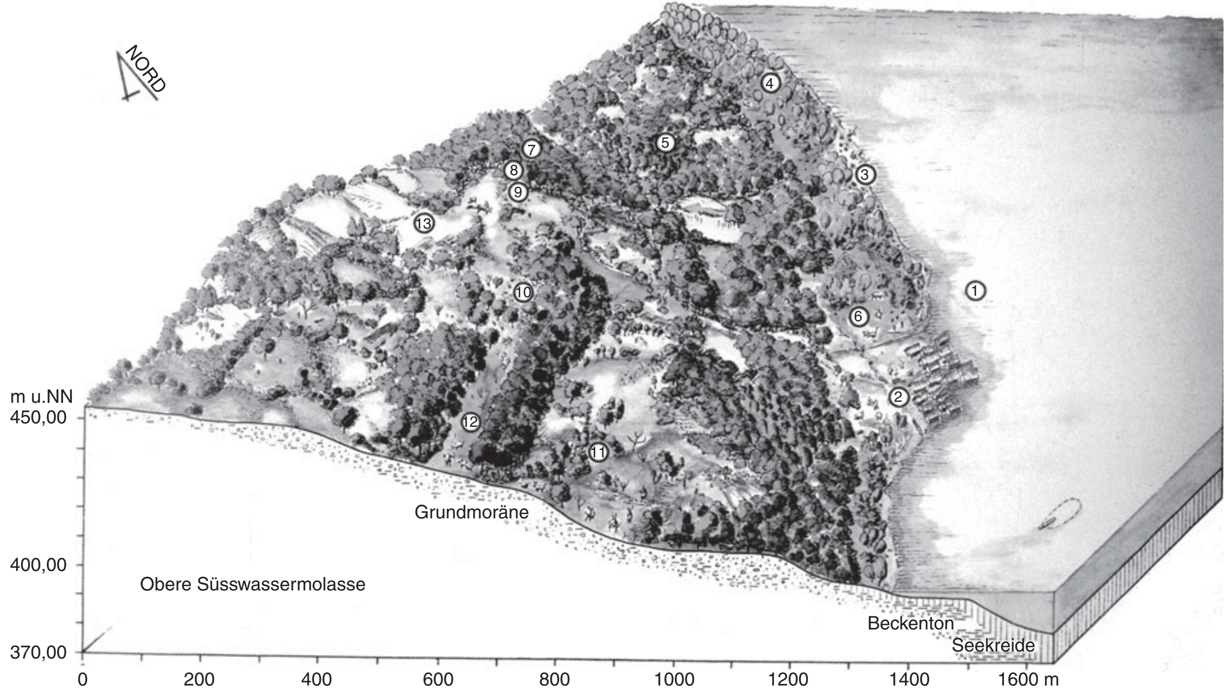


Fig. 3.1. Landscape reconstruction around the Neolithic site of Hornstaad-Hörnle IA, Lake Constance (Untersee), Germany (*c.*4000 BC). (After Maier, 2001: 166, fig. 106) (Key: 1: Aquatic plant community; 2: Weed vegetation; 3: Reed and tall sedge communities; 4: Softwood floodplain; 5: Hardwood floodplain; 6: Substitution vegetation in floodplain forest; 7: Mesophilic deciduous mixed forest; 8: Forest edges; 9: Dry woodland fringe vegetation; 10: Wet woodland fringe vegetation; 11: Lumbered forest; 12: Precursors of grassland; 13: Arable land)

may start a process of regeneration, as the contact with other groups and possible availability of new land may bring the needed socio-economic and technological innovations to fight stagnation or recession. However, interregional contact is not always straightforward, for interaction between populations can take a variety of forms: from clear-cut mutualism to more complex forms such as commesalism and amensalism (Moran, 2000). In a mutualistic interaction the two groups favour the well-being of one another, but they do not depend on each other for survival. On the other hand, while in a commensalistic interaction one group remains unaffected by the other group's influence (or one group benefits without advantages or disadvantages for the other), in an amensalistic relationship one group hinders the survival of the other. These three forms may result in either the generation of a completely new community, or, more drastically, an inevitable friction between the two groups that could lead to belligerent behaviour.

Adaptability to Environmental Constraints

Human studies always emphasize plasticity and flexibility of people's response to environmental variability, whether the stress is caused by unexpected climatic conditions, or by willing choices to settle in a new environment. There are various approaches to the study of human adaptability, but all of them stress the importance of understanding how populations interact with each other and their environments, attempting, at the same time, to accommodate themselves to specific environmental constraints. In this way the environment ceases to be an over-generalized context for human action, and the scope of particular investigations becomes more specific (Kormondy and Brown, 1998). The identification of particular problems does not mean that studying entire biomes is impossible. However, since our knowledge of any entire biome is still fragmentary, it may, for instance, be advantageous to divide the biome into species for study, or to focus on particular regional population behaviours within a specific biome. Especially with the latter approach, it is always crucial to identify the living factors that draw human response, and, accordingly, consider more than one possible answer to the problem. Responses to environmental stress are variable and depend upon the forms of stress that people and populations are exposed to. For instance, constant stress may be coped with by irreversible physiological change during the developmental period of the individual. Developmental responses are adjustments of the organism to environmental conditions that prevail during the growth of an individual. During this time, the physical parts of a person mould themselves to cope with environmental stress. Developmental adjustments have little value for short-term environmental change, but they are definitely more flexible and rapid than genetic change (Frisancho, 1993).

Conversely, acclimatory forms facilitate the adjustment of individuals after the development is completed. They are usually reversible, occurring only when an external stimulus is present for a sufficient period of time; when the stimulus ends, the organism goes back to its previous state. The most common forms of adjustment are behavioural, social, and cultural, and they are also known as regulatory adjustments. The latter type (regulatory) is more flexible than the two previous ones as it involves less commitment by the physical organism (see below); at the same time though, cultural and psychological aspects may be stressed to the limit (Harrison and Morphy, 1998).

Human adaptation studies should always take into account the fundamental ecological unit that includes species of living organisms, the functional relationship amongst them, and their association with the environment; in other words, the ecosystem. A group or community within a specific ecosystem adjusts to the environment in specific ways that reflect both present and past conditions. If a group has lived in a particular environment for a long time, that community is more prone to have developed physical and/or cultural characteristics designed to cope with the constraints of that specific environment, than is a population that has recently settled in the same area, coming from a totally different environmental context. When the newcomers arrive in a new environment, it may take them quite some time to adapt. The amount of time they need and the extent to which they will be able to settle in satisfactorily depend upon the differences between their previous natural habitat and the new one, as well as a combination of the three above-mentioned kinds of response (developmental, acclimatory, and regulatory). Whether the newcomers are settling a populated or unpopulated area also plays an important role in their final success or failure. Social interaction with already established groups in the area may certainly facilitate the settling process, although, as noted above, amensalistic ways of interaction could hinder it significantly (see 'Displacement and Migrations', below).

Physiological Responses

As discussed throughout the chapter, processes of human adaptation take various forms, from physical to social and cultural (see below). Similarly, environmental change (with a special emphasis on climatic oscillations) may influence different aspects of a society, although the two most sensitive ones are often subsistence and economy. Crop failure, for instance, may cause food shortage, which in turn could trigger dietary modifications and economic instability. Whether it is a simple change in diet or a more drastic economic breakdown, either will trigger physiological reactions within the body to enable it to cope with external environmental stress. Among the most common is body temperature variations. The temperature of a healthy human body is usually between 36.5 and 37°C; when it exceeds or goes below these

values the organism experiences discomfort. In order to avoid this situation the body is capable of countering drastic environmental temperature oscillations. High temperatures are countered by sweat production, whereas cold is compensated for by increased kcal burning to produce more body heat. From a dietary perspective, low environmental temperatures are met by an increase in protein-rich food consumption, which itself produces more body heat (Lasker and Mascie-Taylor, 1993). Loss of body heat is, however, not the same in all individuals; in fact, it often depends on the body composition (e.g. fatty deposits) and the size to weight ratio of the person. Age also plays an important role. Because of their low basal metabolic rate (BMR), infants are particularly vulnerable, although they too have specific ways of protection. One of them, which interestingly enough is also present in cold-acclimatized adults, is brown adipose tissue, a non-shivering form of thermogenesis (Eveleth and Tanner, 1990). The physiological functioning of the human body requires that calories be provided to compensate for those used for body maintenance, physical activity, growth, and reproduction. The energy requirement of the body varies according to the activity carried out, body size and climate. For instance, food procurement has one of the greatest impacts on the structure and function of social groupings. People's close relationship to their habitat has always played a crucial role in subsistence strategies: it is vital to know when a particular food is available, and what is edible and what is not. People even know how to treat food, for instance how to detoxify poisonous plants and transform them into valuable staple food, such as the carbohydrate-rich manioc (*Manihat esculenta*) flour produced after soaking and heating the plant (Dufour, 1990); or the leaching process used to remove tannins and make acorns more digestible, a practice commonly carried out, but particularly on the Northwest Coast of North America and in Japan (Croes et al., 2009).

Despite this intimate knowledge of food availability, processing, and preparation, most past populations did experience periods of pronounced food scarcity. With the introduction of farming, the opportunistic and balanced hunter-fisher-gatherer way of food procurement changed dramatically. The uncertainty of the hunt was balanced with more secure harvesting of domesticated plants. However, the delicate crops were more subject to climatic variations, and a good harvest could potentially turn to a disaster the next season. The timescale over which climatic change occurs also plays a crucial role. As Dean (1989) points out, it is therefore important to distinguish between high-and low-frequency processes of variability. High-frequency processes (HFP) occur in periods of seasonal, annual, decadal scale, whereas low-frequency processes (LFP) in periods longer than a generation (about twenty-five years). People's responses to HFP differ from those to LFP, and they depend upon the degree to which a group can mitigate the effects of rapid change. At the same time, significant readjustment may occur with LFP change, which lowers the productivity of critical resources below the limit of

the maintenance of a population. In case of prolonged unfavourable climatic conditions, drastic measures would be adopted to balance the scarcity of food. These measures could be either temporary (lasting only a few years, therefore difficult to detect in the archaeological record), or extending over a long period of time (two or more generations). In the latter case, the repercussions on the natural environment could be catastrophic, resulting in an over-exploitation of wild fauna, which in some cases brings specifically targeted species to extinction, or close to it (see Box 3.1).

Box 3.1 Climate Change and Socio-economic Adjustments in Prehistory: Neolithic Red Deer Over-exploitationon, Lake Zurich

Whether abrupt or of more gentle intensity, climate change has always been a fairly common phenomenon in the Circum-Alpine region. As highlighted by palaeo-climatic charts (Suter et al., 2005: 18), phases of favourable alternated with unfavourable climatic conditions, influenced the delicate relationship that people had with their surrounding environment. The intensity of people's adjustment to climate change depended upon a myriad of socio-economic and environmental factors. In some cases minor adjustments would be enough, whereas in other cases drastic measures had to be taken, as happened on Lake Zurich in the first part of the fourth millennium BC. Archaeozoological studies (Schibler, 2004, 2006; Schibler et al., 1997*a*) show a significant increase in red deer hunting activity at the beginning of the thirty-seventh century BC, which coincided with an abrupt deterioration of climate (colder and wetter). The intensity and frequency with which the red deer was hunted almost caused its extinction. A number of reasons as to why hunting activity increased so significantly have been discussed, and the most plausible one seems to be linked to the limited amount of cereals available in that period. The equation is promptly solved: climate deterioration caused crop failure, which led to an increase in hunting activity to compensate for food scarcity. An interesting development that resulted from this socio-economic adjustment to environmental change was the long-term transformation of a specific artefact technology (stone axe antler sleeves) that not only lasted during the environmental crisis, but remained in the region centuries later.

Climate and Subsistence Crisis

Correlations between palaeo-climatic charts and prehistoric lake-dwelling occupation in the northern Circum-Alpine regions show a tendency for the lake shores to be settled during phases of favourable climate (Magny, 1993, 1995, 2004*b*). There were, however, phases when the lake shores were occupied despite unfavourable climatic conditions. Climate deterioration

continues

Box 3.1 Continued

may have not influenced the lake-dwellers directly (e.g. lake-level fluctuations and floods), but it certainly had a negative impact on the subsistence and economy (e.g. crop failure). When it occurs and how bad it is also play a crucial role. Historical records show, for instance, that the extent to which bad climate influences agricultural activities depends on the season in which bad weather occurs. In the Circum-Alpine region and surroundings, it is cold and wet summers that cause major crop failures (Pfister, 2001). It has to be said, though, that 'too' good weather may also have negative repercussions on agricultural activity. In fact, excessively high summer temperatures and prolonged droughts may affect the already not very fertile soil, and this too, could result in crop failures (Schibler, 2008). A persuasive example is the economic and environmental crisis in Switzerland in the 1540s. That year, lack of precipitation from April to August and the disproportionate heat in the summer caused a major drought, which affected both flora and fauna. As a result, agricultural activity was severely damaged and a number of animals (wild and domestic) died of starvation (Glaser et al., 1999).

Socio-economic Adjustments

The insufficient availability of staple foods resulted from climate deterioration in the thirty-seventh century BC forced the Lake Zurich lacustrine groups to seek alternative nutritional solutions in order to improve a low-calorie diet. The adjustment strategy adopted by the lake-dwellers was, in this case, an increase in hunting activity. The intensity of hunting was so pronounced that it had catastrophic repercussions on the wild fauna, especially red deer, which faced near extinction in the Zurich area between 3660 and 3600 BC (Schibler, 2004; Schibler et al., 1997*a*). This is confirmed not only by the decreased number of shed antlers, but also by the LSI (Logarithmic Size Indices) on red deer bones, which, as Schibler (2001*b*, 2006) notes, fell significantly during that period. A decrease in LSI value is indeed a reflection of increased hunting, which caused a weakening of the species and a consequent reduction in the animal size. Conversely, an LSI increase (less hunting) occurred between 3200 and 3000 BC, and between 2700 and 2500 cal BC (Schibler, 2006) (see Fig. 3.2), when climatic conditions improved. It has to be noted though, that even within these periods there were phases of high hunting activity, but they were probably too short to influence the animal size.

More hunting was not the only alternative sought by the lake-dwellers to replace the unavailability of cereals. An increase in gathering (mainly plants, fruits, and nuts) is also noted. A convincing example is the thirty-seventh-century lake settlement of Zurich-Mozartstrasse, where a fairly

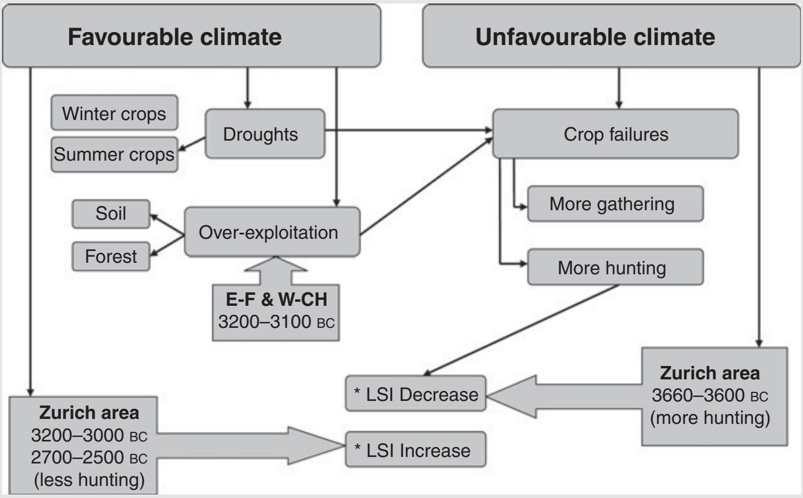


Fig. 3.2. Negative repercussions on crop cultivation caused by either favourable or unfavourable climatic conditions in the northern Circum-Alpine region lake-dwelling tradition. (Key: * LSI = Logarithmic Size Indices; E-F = Eastern France; W-CH = Western Switzerland)

high proportion of hazelnuts was found in layers 4 and 5, along with a high number of wild animal bones and a low quantity of cereals (Brombacher and Jacomet, 1997) (see Fig. 3.3).

Material Culture Change Resulting from Red Deer Over-exploitation

Not only did red deer over-exploitation in the thirty-seventh century BC cause an economic crisis amongst the Lake Zurich Neolithic groups, but it also affected and eventually changed a long-lasting tool-making technology: antler sleeves for hand axes. A sleeve is a hollow section obtained from red deer antlers that is placed between the stone blade and the wooden handle to absorb the shock (Fig. 3.4), and prevents the handle and the stone blade from fracturing (Schibler, 2004).

The excessive hunting of the red deer brought the species to the brink of extinction, thus reducing the availability of antlers significantly. As a result, the lake-dwellers were forced to change the way the stone blade was secured to the handle. In fact, from the thirty-sixth century BC onwards, and for the entire duration of the unfavourable climatic conditions in eastern Switzerland, the stone blade was attached directly to the wooden handle. What is

continues

Box 3.1 Continued

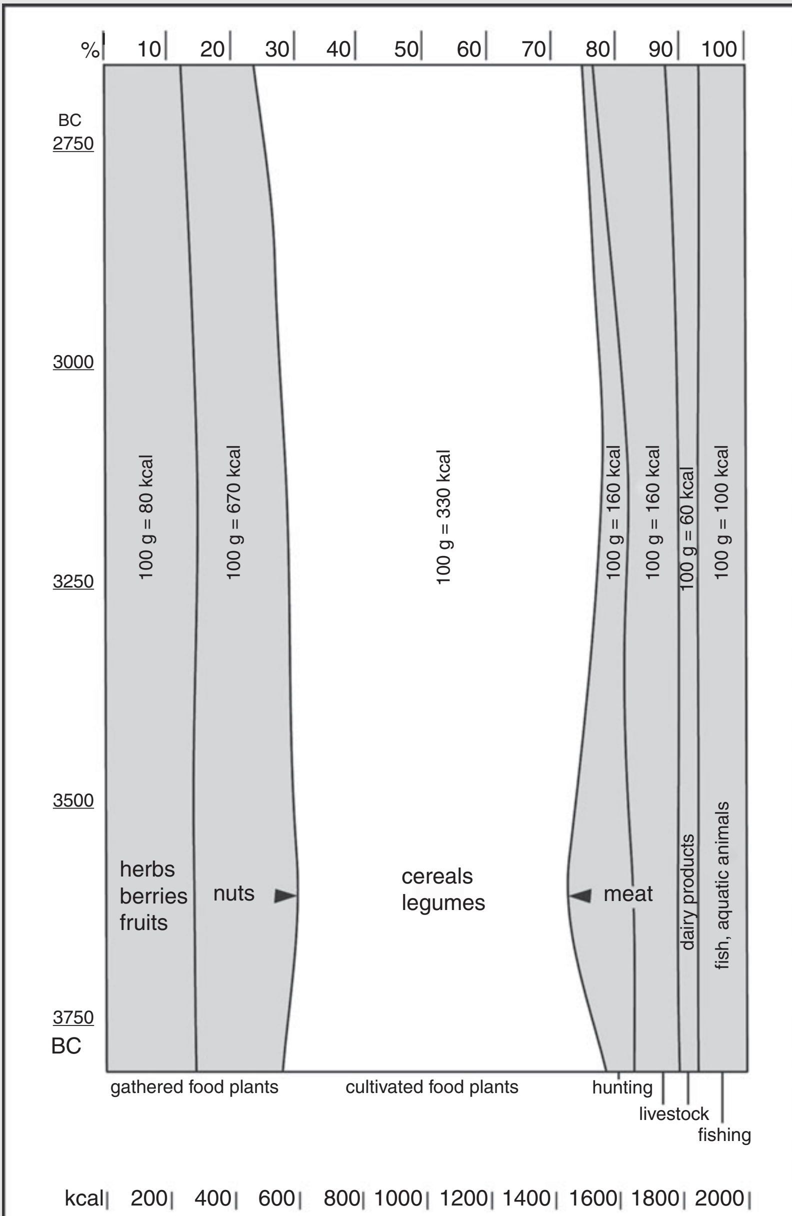


Fig. 3.3. The increase of plant, nut, and meat consumption (instead of staple food—cereals) on Lake Zurich, in the mid thirty-seventh century BC. (Modified from Suter and Schibler, 1996: 24)

even more interesting is that even when the climate crisis ended, and the red deer population had fully re-established itself, stone blades continued to be encased directly in the wooden handle for some centuries to come. This is clearly shown by Arbon-Bleiche 3 (eastern Switzerland), occupied between 3385 and 3370 BC (about three centuries after the crisis), from which, despite its high amount of antler artefacts (burins, awls, spearheads, etc.), antler sleeves were completely missing (Deschler-Erb et al., 2002). It was not until the thirty-first century BC that the sleeve technique appeared again in the region (Hafner and Suter, 2000).

Fig. 3.4. Antler sleeve for a stone axe. (*Photograph*: F. Menotti)

The red deer over-exploitation in the Lake Zurich region is a distinct example of a series of socio-economic regulatory adjustments adopted by typical Neolithic farming communities in response to climate variability. Crop failure caused by climate change induced people to chance their food procurement strategy. This not only affected the ecosystem (in particular red deer population), but had long-lasting repercussions on the community's material culture. Notice, though, that while the ecosystem regained its balance after the environmental crisis, technological traditions proved to be more reluctant to change.

Another crucial element linked to physiological responses to environmental variability is the daily rhythm, also known as circadian rhythm, whereby environmental synchronizers such as light, temperature, and social interaction set the balance between the activity and inactivity of an individual. But, just as these elements can set a biological clock, they can also desynchronize it, causing serious damage that may result in fatal diseases such as tumours. A typical example is the lack of light in the Artic Circle in winter, which causes a decline in people's vitamin D autosynthesis; this results in a lowered intestinal

capacity to absorb calcium, rendering people hypocalcemic for a significant part of the year (Frisancho, 1993; Hastings, 1998; Laughlin, 1975).

Socio-cultural Regulatory Adjustments

Cultural adjustments are strictly linked to the surrounding environment and, in order to be successful, they require a broad knowledge of and familiarity with the various natural phenomena. Knowledge of the environment is crucial, as it influences a variety of aspects including house construction, clothing, subsistence technology, and sacred activity such as rituals and beliefs. Socio-economical organization is included in social adjustments, which are of course interwoven with cultural adjustments as well, providing an extremely variable set of regulations in relation to environmental change and socio-economic relations between the various populations. Climate and environment influence, for instance, the way houses are constructed; from the thick-walled buildings in dry and hot regions, acting to reduce human heat production and heat gains resulting from radiation and convection, to the peculiar entrance pit and long underground passage of the Inuit winter dwellings, especially designed to permit a gradual heating of cold air before it enters the inhabited part of the house (Rapoport, 1969). House architecture reflecting environmental constraints is also common within wetland settlements. A variety of house types was, for instance, developed throughout the lake-dwelling tradition in the Circum-Alpine region, ranging from houses on stilts on the shores of highly dynamic lakes (with marked seasonal lake-level fluctuations, e.g. Lake Constance), to dwellings constructed directly on the ground (but nevertheless carefully insulated, e.g. Lake Feder) in wetland environments less prone to periodical floods (Menotti, 2001*a*, 2004*b*; Schlichtherle, 2004). However, as is pointed out in Chapter 4 (under 'Settlements and Houses'), house architecture in the wetland is also often dictated by purely sociocultural factors (see e.g. the crannogs in Ireland and Scotland, the artificial island settlements in the Masurian Lake of Poland, and the *terramare* in northern Italy).

Adjustments to the distribution of resources and their associated social and cultural factors are also reflected in settlement patterns. As a result, marriages, next of kin divisions, and household structures may determine the layout of the inhabited area (the proximity of houses to one another, internal space division, etc.). Social organization of communities and their strategy for subsistence are also subject to adjustment processes linked to environmental factors. For example, in a hunter-fisher-gatherer group subsistence depends upon the primary productivity of the territory. It is therefore important that the balance between primary productivity and exploitation of the territory is safeguarded. Since prestige seeking within a group is not linked to extra production, when the group is optimally adjusted the work effort is kept to a low level and accumulation is avoided. On the other hand, gift-giving is frequent and believed to be vital to maintain healthy

social relations (Moran, 1995). Small local groups can also be linked together by ties of marriage in a large-scale shared territory, resulting in a tribal form of organization, which allows external influence (the presence of members of other communities). A tribal group elicited by an external social drive may lead to more complex forms of organization, or even to the development of ranked societies, where prestige as well as access to resources is differentially shared. A ranked society is usually led by a chief whose power is assured by generous redistribution of goods taken from the various groups under her or his control (Ellen, 1982; Odum, 1971). In some cases, redistribution may be a means to improve social relations or social status and/or to establish warfare allies, as was the function of yam feasts amongst the New Guinea populations (Brown and Podolefsky, 1976; Dwyer, 1990; Morren, 1986). In the absence of more complex exchange systems and lack of food surplus management, these forms of redistribution are crucial for survival, as they may be used to prevent famine caused by natural disasters such as drought, floods, and other forms of environmental hazards.

Migrations and Displacement

What is it that motivates people to leave the known for the unknown? Reasons may be political, social, economic, or simply personal, but they all have something in common: the interaction between indigenous and intrusive populations. A typical example of migration, which includes, colonization of new territories, social interaction, and different forms of acculturation (mutualism, commensalism, and amensalism) is the Neolithization of Europe. The idea of mass colonization has a long intellectual history in Europe, spanning from the seventeenth-century idea of repopulation after the flood, to Childe's theory of colonization of Europe by farmers, developed in the 1950s (Childe, 1957). In the 1970s and 1980s, this uniform demographic expansion approach was fuelled by Ammerman and Cavalli-Sforza (1971, 1984), who were able to show a progressive advance of farming societies from a genetic point of view. At the same time though, strong criticism of the migration approach started to develop, stressing the importance of local continuities (Barker, 1985). A compromise between the two conflicting views was that of Graeme Clarke, who argued that low- and high-populated regions would have both played a crucial role in the farmers' expansion (Clarke, 1976). With a few exceptions (e.g. the Circum-Alpine region, the Carpathian Basin, and the Danube drainage system), Clarke (1976: 468) maintained that Europe would have had specific areas with higher Mesolithic population density, but only on the outside, as opposed to the inside which would be much less populated. The propagation of farming had therefore two different outcomes; contact would have reflected diverse but parallel responses in areas with relatively dense local populations (see the Megaliths area), whereas in territories with less

Mesolithic demographic density, the foundation and development of new-communities would have prevailed (see the spread of the *Linearbandkeramik*—LBK) (Sherratt, 1995). There were also areas with high-density local Mesolithic populations that nevertheless underwent a full process of acculturation with the advancing LBK cultural groups. A good example is the transition from the Starčevo to LBK on Lake Balaton (Bánffy, 2000). Acculturation processes are not easily spotted in the archaeological record. However, comparative analyses of well-preserved basketry remains from waterlogged sites and pottery decoration patterns have been able to identify skeuomorphic representations of Neolithic pottery (reflecting basketry-making traditions) produced by those farmers who came in contact with native Mesolithic groups (Gronenborn, 1998; Lüning, 1989). A more resilient acceptance of the Neolithic life is noticeable in some areas of northern Europe, Scandinavia, and the Baltic Sea regions. Here, relationships between contemporaneous Mesolithic and Neolithic groups would be maintained by exchange networks of exotic goods (Zvelebil, 1998, 2006; Zvelebil and Lillie, 2000).

Social Push Factors vs. Demographic Pressure

Economy and subsistence strategies are not the only two main factors that motivate people to migrate to uncharted territories. A third reason, often assumed since it is difficult to identify in the archaeological record, is demographic pressure. Personal motivation derived from the socio-hierarchical structure of the group might even be a more plausible explanation. For instance, Kopytoff (1987) argues that in particular African societies social status associated with age gives older brothers higher social status, denying younger ones the opportunity of prestige and social advancement. Hence, ambitious younger brothers migrate to new areas where they can attract new followers and gain higher social status and influence. In this case, although it may look as though it is caused by demographic pressure in an overcrowded environment, migration is instead a social strategy to access power and prestige. Similar situations are found in populations with a rigid gerontocratic social structure, where young, ambitious people are forced to leave, because they are denied higher social status by the older members of the group. Also in this case migration is a tactic to climb up the social hierarchical ladder, not a result of demographic pressure (Molleson, 1994). Another possible cause of migration is the male escape from female-centred societies (Hodder, 1990, 2001). As Cauvin (2000) argues, the outward movement of Pre-Pottery Neolithic B (PPNB) agricultural populations was probably caused by a shift from a female-centred universe to an outward-striving male ideology. Finally, migration processes may have even been linked to hunting activities. Gronenborn (1999) suggests that LBK hunter-warriors may have played a crucial role in the expansion to new territories, and new settlements may

have been founded by them during hunting trips in search for richer hunting grounds.

Coercive Displacement vs. Migration

Whether economically or socially driven, migrations are mostly seen as willing decisions to move to a new territory in search of better living conditions. There are cases, though, when migration is coercively generated by unexpected environmental calamities caused by abrupt and/or long-term climatic variation. Coercive displacement may take various forms, from seasonal (temporary flooding of river deltas and/or lacustrine areas) to permanent, as the result of long-term obstruction of the inhabited area. A typical example is the Middle Bronze Age lake-dwelling displacement in the northern Circum-Alpine region, triggered by a severe deterioration of climate that altered the hydrological balance of the lakes (Menotti, 2001*a*) (see Box 3.2). Semi-permanent/permanent displacement can also be caused by sudden catastrophes such as mudslides (see Ozette, Northwest Coast, United States), or volcanic eruptions (e.g. Nola and Pompeii, Italy). A third form of displacement is a combination of environmental social and economic factors, deriving from demographic pressure linked to migrations, as happened with the Late Neolithic lake-dwellings of Lake Chalain (France). Here, following the influx of external cultural groups (the Eastern-Swiss Horgen groups, south-west Ferrières groups, and north-western groups from the Saône Plain), as well as favourable climatic conditions, the demography increased considerably between 3200 and 3000 BC (Arbogast et al., 2006; Pétrequin et al., 2005). The higher demand for food production and house-building material triggered a series of socio-economic adjustments, such as more hunting, the over-exploitation of agricultural land, and the use of primary forest (to obtain house-building material). The economic crisis was eventually avoided by migrating to another region (e.g. the Lake Clairvaux) in search of new available natural resources (Arbogast et al., 2006).

Box 3.2 The Northern Circum-Alpine Region Middle Bronze Age Lake-Dwelling Displacement: Cultural Adjustment to Environmental Stress

A characteristic of the 3500-year long Circum-Alpine region lake-dwelling tradition is its lack of continuity. There were periods when the lake shores were fairly densely occupied and other periods when they were completely deserted. Occupational hiatuses were caused by a number of factors that can be summarized in two main categories: environmental and cultural. While Magny (1993, 1995, 2004*a*) notices, for example, a correlation between

continues

Box 3.2 Continued

climate and occupational patterns (whereby favourable climate coincides with occupation, and abandonment is the result of climate deterioration—see Fig. 3.5), Pétrequin and Bailly (2004), on the other hand, maintain that the relationship of climate to lake-shore occupation does not always work. There were periods of favourable climatic conditions when the lake shores were not settled anyway. It is furthermore important not to consider the two categories (environmental and cultural) separately, since the abandonment itself, even if triggered by the environment, is always the result of a series of socio-economic and cultural variables.

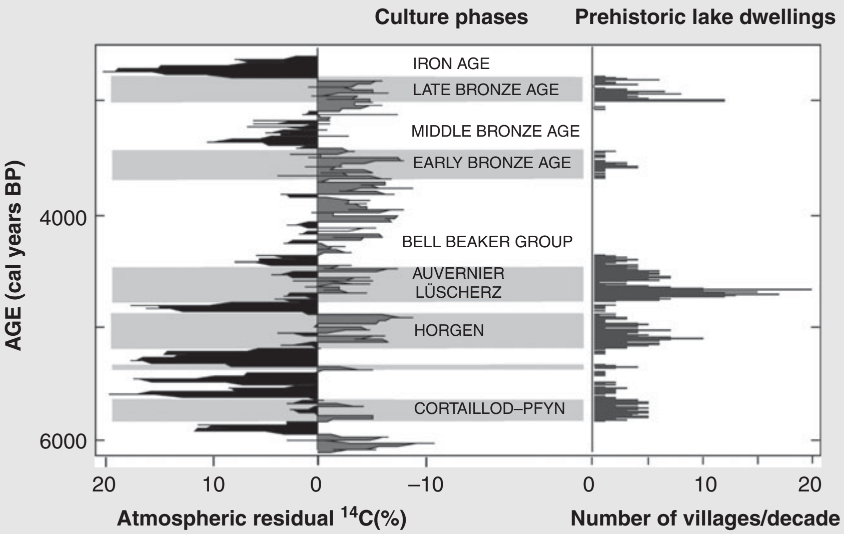


Fig. 3.5. Correlation between the atmospheric residual ^{14}C variations (+ unfavourable climatic conditions; – favourable climatic conditions) and the lake-shore settlement occupations in the northern Circum-Alpine region. (*Graph*: courtesy of Michel Magny, Laboratoire de Chrono-écologie, CNRS, Besançon)

Direct Influence of Climate Deterioration: the Lake-Level Fluctuation Hypothesis

An increase in humidity and precipitation could influence the delicate hydrological balance of the lakes, causing water levels to fluctuate, hence affecting those lake villages located in close proximity to the water. The extent to which the lake transgressions may influence the lacustrine settlements depends upon a variety of factors; from the size, morphology, and hydrological sensitivity of the lake (Magny, 1992), to the typology and

location of the dwellings (Menotti, 2001*a*, *b*). Lake Constance, for instance, is known as one of the most sensitive lakes in the northern Circum-Alpine region. Its normal seasonal water-level fluctuations vary as much as 3 metres between winter (the lowest) and early summer, and/or early autumn (the highest). It is therefore not surprising if two of the last-occupied Bronze Age settlements before the Middle Bronze Age (MBA) hiatus were severely influenced by flooding (see below).

The Middle Bronze Age Hiatus

A striking feature of the MBA lake-dwelling occupational hiatus (fifteenth to twelfth century BC) is the marked direct influence that climate change had on some of the lacustrine settlements before the hiatus began. For instance, three of the last-occupied lake-dwellings, ZH-Mozartstrasse (Lake Zurich), Arbon-Bleiche 2, and Bodman-Schachen 1 (Lake Constance) were all abandoned in the last decade of the sixteenth century BC, and all show traces of flooding occurring during and after the abandonment. GIS spatial analyses carried out on the settlements and surroundings show how drastic the impact of flooding was, when the lake levels reached their maximum expansion (see the simulation of the Bodnam-Schachen area—Fig. 3.6a and b) (Menotti, 1999, 2001*a*, 2002). Lake-level fluctuations have also been witnessed on less sensitive lakes, and even on shrinking morainic lakes such as Lake Feder (Siedlung-Forschner) in Germany (Schlichtherle and Wahlster, 1986), and the former Lake Carera (Fiavé), in Italy (Perini, 1987). It has to be pointed out, though, that only a handful of sites were affected by the transgressive waters, and therefore the main causes of the complete exodus from the lake shores have to be sought within socio-economic factors.

Moving Inland: Cultural Adjustment to Environmental Stress

What happened after the lake shores were deserted? A number of theories have been developed as to where the lake-dwellers went during the hiatus, although recent research seems to point to a close proximity to the lakes (Menotti, 2003). In fact, typological analyses of pottery and other material culture of the Early Bronze Age (before the hiatus) lake-dwellings, and MBA (during the hiatus) ‘inland’ (but not far from the lakes) settlements show remarkable similarities, arguing for a possible common origin.

continues

Box 3.2 Continued

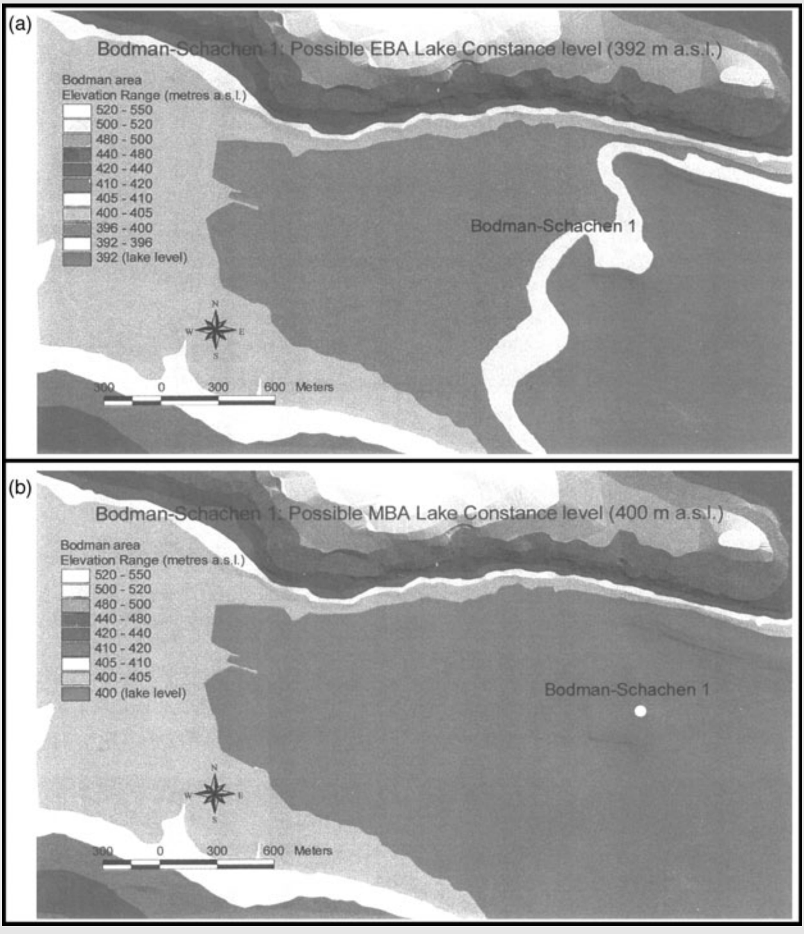


Fig. 3.6. GIS computer simulations of the inferred Middle Bronze Age Lake Constance level in the Bodman Bay, and its influence on the Bodman-Schachen 1 lake-dwelling: a) 392 metres above sea level (before the MBA lake level transgression); b) 400 metres above sea level (Maximal lake-level transgression during the MBA). (After Menotti, 2001a: 138 and 140)

The Kreuzlingen Area: an Irrefutable Proof

Convincing evidence that the MBA lake-dwellers did not go too far inland once they deserted the lake shores comes from a series of MBA sites near Kreuzlingen on Lake Constance. The construction of the N7 motorway (Schwaderloh-Kreuzlingen) between 1997 and 1999 led to the fortunate

discovery a of a few MBA settlements situated on the gentle Kreuzlingen hills, overlooking the Swiss shores of the lake (Rigert, 1999, 2001). The importance of the discovery lies in the fact that the settlements were all located above the 400-metre above sea level last (asl) contour line, which was the maximum expansion of Lake Constance during the Middle Bronze Age occupational hiatus. What is even more astonishing is the chronological order in which the settlements are located in relation to the geomorphological structure of the terrain. For instance, settlements occupied at the beginning of the hiatus lie near the 400-metre contour line, whereas the later ones are futher inland (see Fig. 3.7). Once the transgressive lake level was no longer a threat (beginning of the Late Bronze Age), the lake shores began to be settled again (Menotti, 2003, 2004*a*).

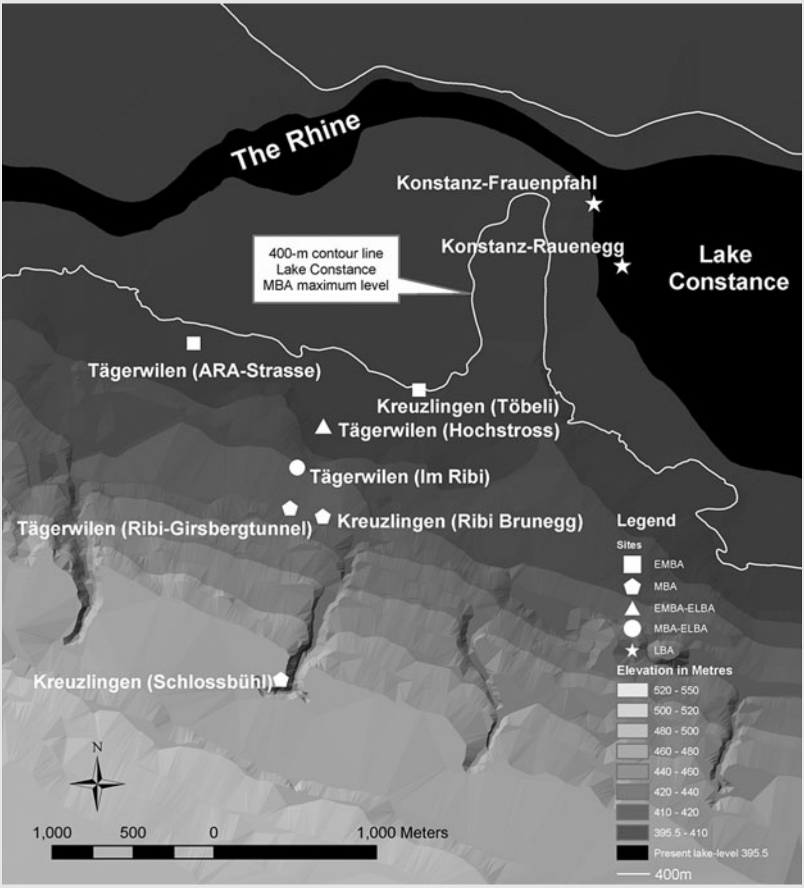


Fig. 3.7. GIS applications of the Middle Bronze Age settlement distribution in the Kreuzlingen inland area on Lake Constance, Switzerland. (Key: EMBA = Early Middle Bronze Age; MBA = Middle Bronze Age; ELBA = Early Late Bronze Age; LBA = Late Bronze Age. (After Menotti, 2003: 382)

continues

Box 3.2 Continued

Responses to environmental variability do not depend only upon economic factors, but also exercise a significant influence on culture in general, hence shaping the society's organization and providing the conditions that give rise to social change and transformations. Adaptation to a new area causes social adjustments, which are themselves reflected in the community's material culture, especially if the newly settled area is different from the previous one. A severe change in climatic conditions forced the MBA lacustrine communities of the northern Circum-Alpine region to relocate themselves. Some of them were influenced directly (by lake-level transgressions), some others chose (or were forced) to leave for other motives. Whatever the reason might have been, the result was the same: a total abandonment of the lake shores until the threat receded. But no matter how intense the threat, a close contact with the lake was never lost.

Expanding and Adapting to New Environments

Colonizing or moving to new environments requires knowledge about natural and cultural (if already occupied) aspects of the unfamiliar area. Social response to new environments may include a total lack of knowledge of natural resources and their distribution, and/or lack of access to previously acquired knowledge of the distribution of unfamiliar (but not necessarily totally new) natural resources (Rockman, 2003). Acquiring knowledge about a particularly new landscape is called the 'landscape learning process' and is most likely to occur in situations of initial occupation (an area not as yet encultured by people). However, there are cases where areas had been settled previously (and were still occupied). This, depending on a variety of factors (different forms of acculturation) already discussed above, may or may not facilitate the learning process of the newcomers. There are various ways with which landscape learning can be integrated into archaeological studies, especially concerning the settling of new environments. Landscape knowledge can be divided into three types: limitational, locational, and social, which themselves form a series of research approaches known as landscape, biogeographical, ethnographic, and resource modelling approaches. The landscape approach sees the landscape as a piece of topography bounded by its use by a given group. These boundaries are maintained by the practices of the group and may be created by cooperation and specific social practices within the group itself, as well as by the adoption, absorption, or reuse of the residual traces of previous occupants. A technique for gauging this is the retrogressive analysis, whereby the interpretation moves from a well-known landscape (recent past) to a sequence of

progressive earlier antecedent phases (Tolan-Smith, 1998, 2003). In contrast to landscape approaches that deal only with the development of locational knowledge supported by social knowledge, the biogeographical ones study the limitational knowledge supported by locational and social knowledge. It is crucial to recognize the relationship between knowledge and what people see as a suitable habitat, without taking for granted that they will occupy all possible areas of such an environment. Some areas may be temporarily unsuitable, becoming suitable only through adaptation, in other words, through overcoming specific barriers. There are a number of possible barriers, and these could themselves develop further (e.g. become more insurmountable), or dissolve in relation to a number of different social and environmental factors (Gamble, 1993). Rockman (2003: 15) suggests three main types of barrier: population, social, and knowledge barriers. Population barriers refer to compatibility with resident populations; in other words the availability or otherwise of suitable physical landscape space in an already occupied area (Lattimore, 1962). Social barriers are obstructions of information transfer between groups, due to different social organizations within them, including language and other social factors linked to information transfer. Knowledge barriers are related to the availability of environmental information necessary to be able to settle a new area successfully. Even in an already occupied landscape, the existing population may not have the right information needed by the colonizing group, which therefore has to gather its own from scratch (Bogucki, 1979). The three above-mentioned types of barrier are not to be considered independently. In fact, they often appear together, although in rather different scenarios. For example, a population colonizing a new territory (e.g. not inhabited by other groups), may encounter higher knowledge barriers, but the other two types (population and social) are not present. Conversely, when a colonizing group comes across resident populations, the knowledge barrier is lower (especially if they share similar economic systems), but social and population barriers are higher. Interestingly enough, if the two latter are high enough, friction may occur and some relearning may be required; in some cases, the settling process may even resemble that of an initial colonization (Rockman, 2001, 2003). The ethnographic approach emphasizes the development of social knowledge enlightened by both locational and limitational knowledge. Information is gathered from two sources: (*a*) direct individual exploration and experience (Binford, 1983), and (*b*) when knowledge is incorporated in social practice, interaction, and lore (Minc, 1986; Moodie et al., 1992). In both cases though, it is difficult for the ethnographers to gauge the abilities of people, and single groups, to experience a new environment successfully (R. Kelly, 1995). The assessment of natural resources variability and its relationship to the possibility of transferring information between groups derives from a combination of locational, limitational, and social information. The similarity of needed resources (location, distribution,

and limitation) determines the prospects and success that new settlers (deriving from a similar environment) would have to use that information in the new area (Rockman, 2003). A good example of identifying processes of colonization by taking into account environmental change, resource availability, and adaptation, including cultural factors and technology, is the first inland occupation of the northernmost Finnish Lapland and Norway. Contrary to what was previously believed, inland colonization is more likely to have had a southern, inland origin than a northern, coastal one. This argument is not only supported by lithics distribution linked to south-eastern inland populations, but also by the fact that these inland groups were very well adapted to the boreal forest, which also followed a northerly expansion in the same period (*c.*9000–7000 BP) (Hicks and Hyvärinen, 1997). The adaptation of coastal populations to the advancing forest would have been much harder, and, considering the availability of food resources on the coast, an inland move would have been counterproductive (Rankama, 2003). This fits well with the Neolithization of Europe discussed above, where 'empty' niches suitable for agriculture would be colonized by migrating farmers much more easily, since not only were those areas not inhabited by Mesolithic populations, but the incoming groups were already familiar with similar environments.

CONCLUSION

People's relationships to their habitat are a complex combination of cultural, behavioural, and physiological factors. Single individuals and social groups are often forced to adapt and/or adjust to the surrounding environment by a myriad of internal and external influences, such as long- and short-term climate change, natural calamities, internal group social pressure, and demographic as well as economic instability. These stress entities (also known as stressors) are all linked and interwoven with one another, and, in most cases, each of them is capable of triggering a series of chain-reaction events that will affect all the others.

We have seen how the primary biological productivity of ecosystems influences the quality and quantity of the available resources. As a result, a basic knowledge of the natural habitat is crucial, and will determine positive or negative outcomes in the process of adaptation to a new area. Since people are themselves an integrated part of a given ecosystem, their physiological capability to mitigate change is also germane for the stability of the ecosystem itself. The case-study discussed in Box 3.1 is a clear example of the influence of a single stressor triggering a chain reaction of events with a multitude of repercussions on both people and the environment; climate change influences

the environment, which in turn affects people's subsistence (crop failure), then their physiology (the need for more protein-rich food) causes fauna over-exploitation that eventually results in material culture change (hand axe sleeve technology). It has to be pointed out though, that positive developments (e.g. favourable climate, economic stability, and demographic increment) may also have negative repercussions, such as forced migrations and population displacements. However, migration processes could also be beneficial; they can release social pressure within overcrowded social communities, promote contact with other social groups, and develop new economic impulses. Of course, all this depends on the type of interaction that different communities embark on (see e.g. mutualistic, commensalistic, and amensalistic processes of acculturation). On the other hand, migrations may also mean coercive displacements as described in Box 3.2. Yet again, the final outcome may not be so drastic; forced migrations may, in some cases, even be a good way to avoid subsistence and/or economic crises.

Whether dealing with social or environmental adjustments to internal or external variability, it is always crucial to stress the importance of socio-cultural and environmental learning processes (knowledge and population), which, if properly gauged, could lower barriers that hinder vital development of social interaction.

4

Abundant, Well-Preserved Evidence

INTRODUCTION

One of the most striking features of wetland archaeology is, without a doubt, the archaeological evidence that the discipline deals with. Anaerobic conditions prevent organic materials from decaying, and, as a result, the apparently most delicate and vulnerable artefacts remain astonishingly well preserved. However, not all wetland environments yield the same objects. This is not only due to preservation conditions (see Ch. 5), but to the different ways in which areas were occupied. Within the general term 'wetlands' there are a number of different types of habitat, for instance: lake shores, river banks, swamps, marshy coastal areas, and peatbogs (see Ch. 1). Not only have these wetlands different ecosystems, but also dissimilar geomorphologies and climate, which together influence human occupation (see Chs. 2 and 3). As a result, archaeological evidence may change according to various types of wetland. It is therefore germane to distinguish between the diverse environments and identify the particular kind of archaeological evidence that may be peculiar or endemic to that specific area. This chapter discusses a variety of archaeological evidence, from settlements to people and their material culture. It is, for instance, crucial to recognize the difference between a typical lakeside village on stilts in the Alpine region of central Europe and a crannog in Scotland, or to detect the reason why the ground-joint building technique was preferred to the perforated base-plate method of construction in marshland and/or peatbog-like environments (Gollnisch and Seifert, 1998; Schlichtherle, 2004). It is also important to understand how people moved about in those seemingly inhospitable environments: did they build paths and causeways, or did they prefer waterway communication? For instance, taking into account the large number of canoes (dugouts) found in the wetlands, could it be stated with certainty that this means of transport was the most popular one, or did people have alternatives (Pétrequin et al., 2006*c*; Ruhl and Purdy, 2005)? And, is it really possible to detect the difference between utilitarian trackways and those built for ritual purposes (Bond, 2004, 2009; Coles, 1999*b*; Coles and Coles, 1986; Honegger, 2001; Raftery, 1996*d*)? Finally, concerning people's material

culture, was it really different from that of the terrestrial groups? For example, did they have a particular way of making the pottery (e.g. a particular clay body to temper ratio to withstand the excess of humidity, as used by the Late Tripolye riverine groups in Ukraine (Gey, 1986; Ryzhov, 2008)), or did they use specific species of wood, ones that cope better with humid environmental conditions?

The mystery that often shrouds the wetlands has always created a fertile ground for sacred activities, whether linked to religious beliefs or to pagan offerings and depositions. Interestingly enough though, apart from only a few exceptions (see Windover and Fort Center in Florida, United States, and a small number of dugouts in prehistoric Europe), funerary practice and burials in the wetlands are not very common (Doran, 2001*b*, 2002; Milanich, 1998). However, extremely well-preserved human remains come from peatbogs, where quite a few so-called 'bog bodies' have been discovered in the past few centuries (Coles et al., 1999; van der Sanden, 1996). In some cases, the level of preservation is so good that even facial features (skin, hair, eyelashes, and eyebrow) are still perfectly visible. These incredible discoveries have helped archaeologists shed more light not only on the aesthetic appearance of our remote ancestors, but on nutrition, diseases, and other pathologies as well.

This chapter is not by any means an exhaustive list of house and settlement types, well-preserved organic material culture, special wetland sites, and remarkable remains of bog bodies, but rather a careful selection of places, structures, and objects, either characteristic of wetland environments or simply serendipitously preserved in waterlogged conditions. The main objective of this selection is twofold: first of all to identify those architectural structures (habitations, trackways, alignments, etc.) characteristic of wetland environments, and secondly, to try to bridge the gap of archaeological evidence between wetland and dryland occupations. This is done by identifying objects and artefacts, which are not necessarily typical of wetland sites, but have survived thanks to wet anaerobic conditions, and compare them with those belonging to distinctive wetland groups. The contents of each section and subsection of the chapter have been organized in a descending (older to more recent) chronological order, following, where possible, a west–east, north–south spatial distribution (as in Ch. 2). However, due to cross-referencing between sites and/or lack of archaeological evidence in some areas, vast leaps are sometimes required in order to follow a more consistent argument.

HOUSES AND SETTLEMENTS IN THE WETLANDS

In comparison to the large number of organic artefacts found in waterlogged archaeological sites, the remains of houses and/or settlements are rather

limited. The paucity of residential unit architectural structures in a wetland context depends upon a myriad of factors, such as location, cause of abandonment, site formation processes, climate, environmental change, and, as pointed out in Chapter 5 (under 'Survey'), the identification of such structures. Whether or not the house structures were preserved depends upon all the above-mentioned factors, but one of the most influential is certainly the architectural form of the house itself. In fact, even if one takes for granted an optimal wet location with ideal preservation conditions, the final outcome would still depend on how the house was constructed. Site formation processes vary significantly between a house with an elevated floor and one built directly on the ground, or between a house located in shallow water or on land. For example, the chance that archaeologists find the original floor of a collapsed house built on stilts above the water is extremely slim. House floors constructed directly on marshy grounds have, on the other hand, a much higher prospect of survival, despite the fact that preservation conditions are not ideal (e.g. anaerobic conditions may not be present). In the long run, however, the latter example is more vulnerable to climate and environmental change, and, above all, to human agency (e.g. land management), than the former. As a result, there is more chance of coming across well-preserved, 'distorted' evidence, than poorly preserved, intact evidence *in situ* (see also Ch. 5, under 'Preservation' and 'Conservation'). It is therefore obvious that, even with the most remarkable level of preservation, the following description and distribution of wetland houses and settlements is far from being a true reflection of reality at the time those house and/or settlements were occupied.

Houses in Wetland Contexts

The fact that we are dealing with wetland occupations does not necessarily imply that the remains of habitations in wet environments are always waterlogged. This is particularly true in prehistoric northern Europe and Scandinavia, where, despite the presence of vast wetland ecosystems the majority of settlements were located on slightly elevated grounds. As a result, even though these sites may be covered in several metres of peat (developed after the houses and/or settlements were abandoned) the layout and architectural remains of those residential units resemble more that of a typical terrestrial dwelling (post-holes and inorganic living floors), rather than a wetland one (waterlogged remains of wooden structures). As surprising as it may seem, the oldest evidence of waterlogged archaeological remains of houses does not come from Europe, but from a more unexpected place: South America. In fact, the remains of at least twelve rectangular houses, built with tree stems and branches and dating *c.*12,500 BP have been discovered at Monte Verde, Chile. The huts were covered with mastodon skin (traces of the skin were

still attached to parts of the frames) and there was also evidence of fireplaces inside and outside the dwellings (Dillehay, 1997). In Europe, the first waterlogged evidence of prehistoric houses is not found until the Mesolithic, during which fairly well-preserved living floors in wetland contexts are not uncommon, especially in the northern part of the continent and Scandinavia. Some of those hut living floors even retain traces of post-holes, resembling either the tepee-like structure of Howick hut (northern England) (Waddington, 2007), or the dome-like huts of Mesolithic Lake Feder (Germany) (Schlichtherle and Strobel, 1999), or even the Early Neolithic ones of Matveev Kurgan I, in Ukraine (Krizhevskaya, 1998). However, proper evidence of waterlogged houses is rather rare. One of the best-known examples is the submerged site of Møllegabet II, which yielded a 5 × 3 metre rectangular living floor made of bark, resting on cross-laid branches. A fireplace or hearth is also identifiable (Rieck, 2003). The scarcity of waterlogged house remains in Mesolithic Europe is also mirrored by later (e.g. Neolithic and Bronze Age) sites. The prevailing archaeological evidence of residential dwellings, especially in the northern part of the continent and Scandinavia, is in fact that of living floor layouts and post-holes, where the house superstructure has completely disappeared. Interestingly enough, despite these house layouts being located within wetland environments they are not considered to be wetland sites. One of the best examples is the Neolithic settlement of Bejsebakken (northern Denmark), consisting of 23 two-aisled houses, with and without sunken floors, measuring 5.75 × 14–15.5 metres (Sarauw, 2008). Similar evidence, but in the Bronze Age, is found at Bjerre (Thy, Denmark), where traces of living floors belonging to three-aisled houses measuring 15–25 metres long and 6–8 metres wide have been located on a gentle hill surrounded by marshlands (Bech, 1997). Further south, similar post-hole layouts have been identified at Texel-Den Burg, Angelslo, Zijderveld, and Oss, where Middle and Late Bronze Age houses were even longer, reaching in some cases 30 metres (Fokkens and Arnoldussen, 2008). Other archaeological evidence of wetland houses in northern Europe comes from the eastern Baltic Sea regions and western Russia, and consists of mainly waterlogged wooden piles of seasonal dwellings built of the edges of lakes and marshes. The house superstructures and other architectural characteristics are not preserved. On the British Isles, Neolithic houses within the wetlands are not very numerous either, and none of them (e.g. those in the Fenland) show traces of waterlogged structures. A slightly different situation occurs in Ireland, where evidence of lough shore occupation is certainly present, although, except for a few examples (e.g. Rathjordan, Co. Limerick), almost all of them have not retained any waterlogged house superstructures. Despite the limited number of Neolithic and Bronze Age wetland houses (in both northern Europe and in the British Isles), one can notice a clear distinction in architecture; while on mainland Europe houses are mainly of rectangular shape, those in the British Isles and Ireland are mostly circular. As one

moves south towards central Europe the number of typical wetland (lacustrine and marshland) dwellings found in waterlogged conditions increases significantly. The development of the so-called lake-dwelling tradition in the Circum-Alpine region from the forty-third century BC onwards brought about a totally new way of interacting with the wetlands (see also Ch. 2). People were no longer living on their edges, but within them, constructing fully-fledged settlements (see Boxes 4.1 and 4.3) and developing new architectural trends in house construction.

Box 4.1 Lacustrine Houses of Circum-Alpine Region

Despite Keller's dogma (Keller, 1854, 1866; Menotti, 2001*b*), whereby all lake-dwellings were grouped in a single architectural category, it is now known that the approximately 3500-year-long lacustrine and marshland settlement tradition encompassed one of the most diverse house typology divisions of central Europe, from the Neolithic to the very beginning of the Iron Age. As discussed in Chapter 3, people's reasons for settling in a new environment involve a complex combination of cultural and environmental factors. Once the decision was made though, people still had to adapt to that choice, and house architecture is one the most evident manifestations of the process of adaptation. Although house architecture reflects cultural and psychological aspects of a single person/family/group, it still follows some patterns that are strictly and uniquely linked to the environment only. For instance, while a pile-dwelling can easily fit within a marshland environment, the construction of a house floor directly on the shore of a very dynamic lake (i.e. with significant seasonal fluctuations; see Box 3.2) would be counterproductive. Consequently, a group settling in a semi-wet marshland environment does have the choice between an elevated (pile-dwelling) and a ground floor house, whereas a group settling the shores of Lake Constance could only opt for a pile-dwelling. It is indeed the inevitable combination of cultural decisions and environmental constraints that have created the diverse building techniques and house architecture of the Circum-Alpine region lake-dwelling tradition.

House Typology

The houses of the Circum-Alpine region lake-dwelling tradition were in general all rectangular, but the size varied according to place and time. For instance, a standard pile-dwelling (e.g. Hornstaad-Hörnle 1A, Fig. 4.1) would normally not exceed 4 × 10 metres, whereas a Federsee longhouse (e.g. Seekirch-Stockwiesen, Fig. 4.2) built directly on the ground, would easily reach 5 × 15 metres (Schlichtherle, 2004).

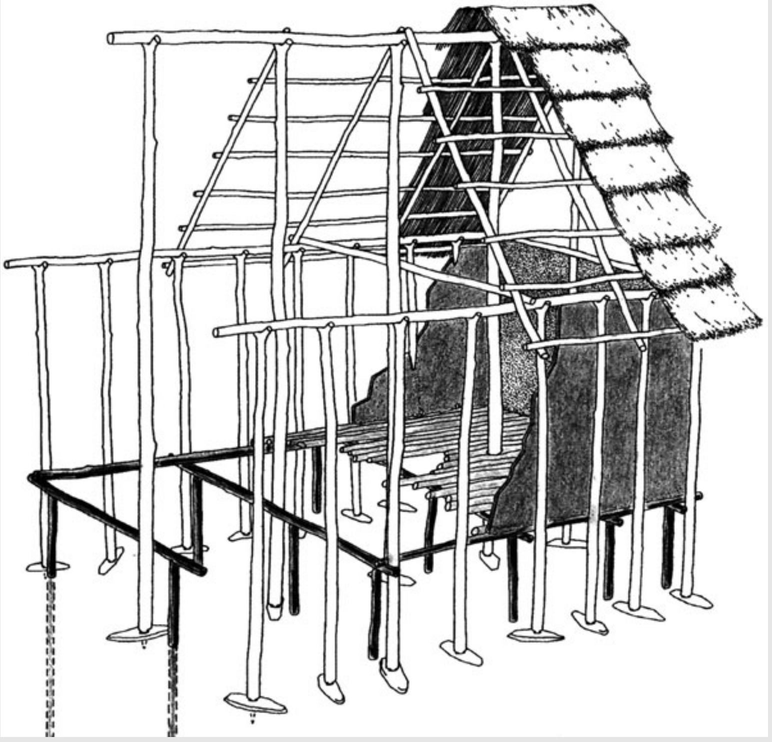


Fig. 4.1. Schematic reconstruction of the Hornstaad-Hörnle A1 Neolithic pile-dwelling, Untersee, Lake Constance, Germany. (*Drawing*: Almut Kalkowski, courtesy of Landesamt für Denkmalpflege Baden-Württemberg, Germany)

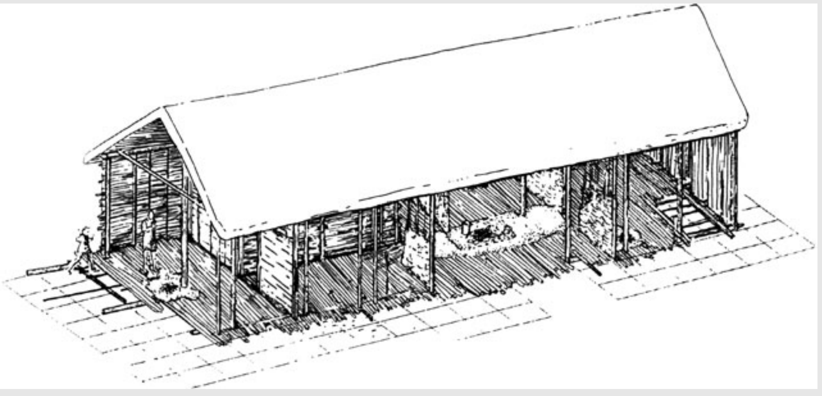


Fig. 4.2. Schematic reconstruction of the Seekirch-Stockwiesen Neolithic house (Lake Feder, Germany). (*Drawing*: Almut Kalkowski, courtesy of Landesamt für Denkmalpflege Baden-Württemberg, Germany)

continues

Box 4.1 Continued

The floor of the latter type is usually made of various strata of roundwood and bark, and it is sometimes covered in clay, whereas the elevated floor of a pile-dwelling consists of half-split small logs or planks, but they, too, are sometimes paved with a stratum of clay (Fig. 4.3a–c). Walls vary considerably in both types; from simple half-split, vertically set small logs to block-construction or wattle-and-daub panels (Pétrequin, 1984) (see also Fig. 4.4a–f).

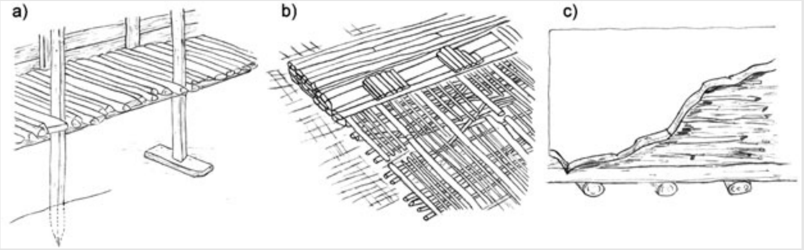


Fig. 4.3. Different kinds of lake-dwelling house floors: a) Elevated floor of a pile dwelling; b) Multi-layered roundwood floor build directly on the ground; c) Wooden floor paved with clay. (*Drawings*: Olenka Dmytryk)

According to the only two examples of house doors: one at Wetzikon-Robenhausen (Lake Pfäffikon, Switzerland) (Eberschweiler, 1990*b*), and the other recently found at Zurich Parkhaus-Opéra (in front of the Opernhaus building), the doors of the lake-dwelling houses seem to have been quite small, ranging from 145 × 55 cm (Wetzikon-Robenhausen) to 153 × 88 cm (ZH-Parkhaus-Opéra). The roof was usually made of reeds or wooden shingles (e.g. Arbon-Bleiche 3), and in some cases also bark from different species of trees. The gabled roof was supported by a series of king posts and the gradient depended upon the cover used; a shingle-covered roof requires less gradient than a thatched one. Both the above-mentioned lake-dwelling architectural types (pile-dwelling and ground floor houses) have themselves various construction techniques, which again may vary according to the geographical location and chronology. For instance, the perforated plate technique (*Pfahlschue*) was used throughout the lake-dwelling tradition from the Neolithic to the Late Bronze Age, but not in the north-western part of the Circum-Alpine region, whereas the block-construction technique and the mortise and tenon joints (Fig. 4.5a–e) developed in the Bronze Age, were used only in the central, eastern, and southern part of the Circum-Alpine region.

An interesting combination of various construction techniques (block-construction and perforated plate, Fig 4.5b and e) is also noticed at the Late Bronze Age settlement of Greifensee-Böschen (Lake Greifen, Switzerland) (Eberschweiler, 1990*a*; Eberschweiler et al., 2007) (Fig. 4.6), and at Ürschhausen-Horn, Lake Nussbaum, Switzerland (Gollnisch-Moos, 1999) (block-construction and the plank-pillar technique, Fig. 4.4a, e, and f).

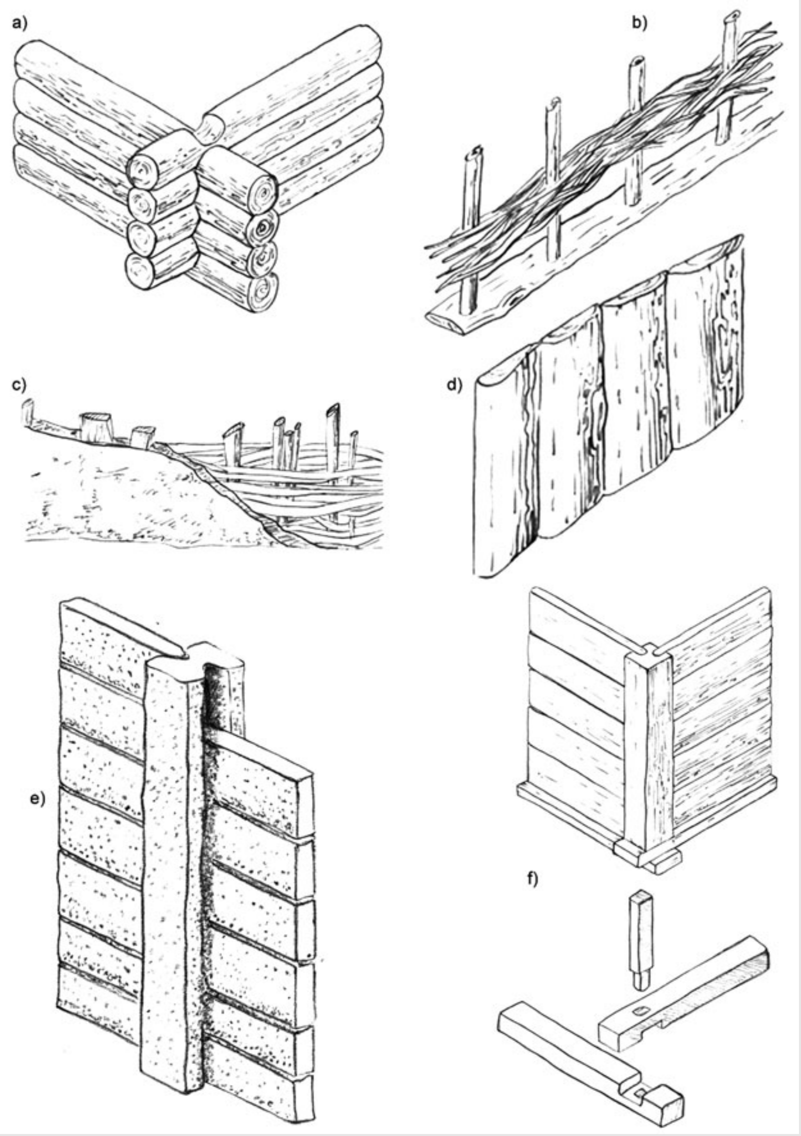


Fig. 4.4. Different kinds of lake-dwelling walls: a) Block-construction; b) Wattle; c) Wattle and daub; d) Split roundwood; e) Plank-pillar; f) Plank pillar with mortise and tenon joints. (*Drawings*: Olenka Dmytryk)

continues

Box 4.1 Continued

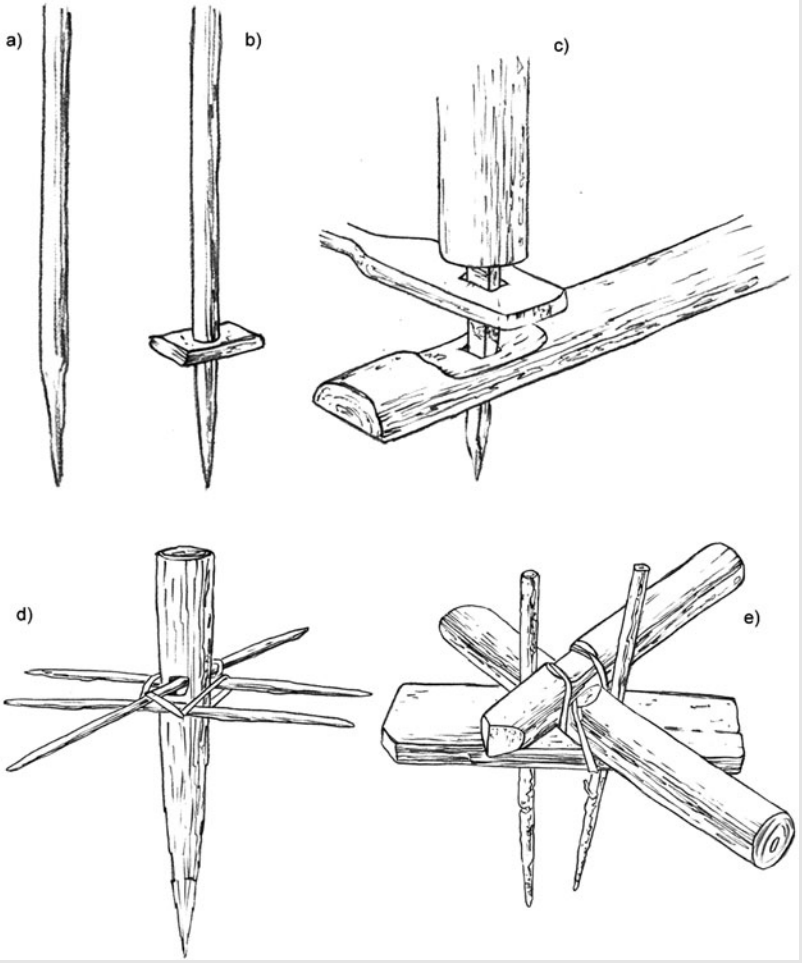


Fig. 4.5. Different kinds of pile stabilizers: a) Plain pile; b) Perforated plate (*Pfahlschue*); c) Ground-joints; d) Perforated pile with bound horizontal sticks; e) Double-perforated plate for block-construction corners.

(*Drawings*: Olenka Dmytryk)

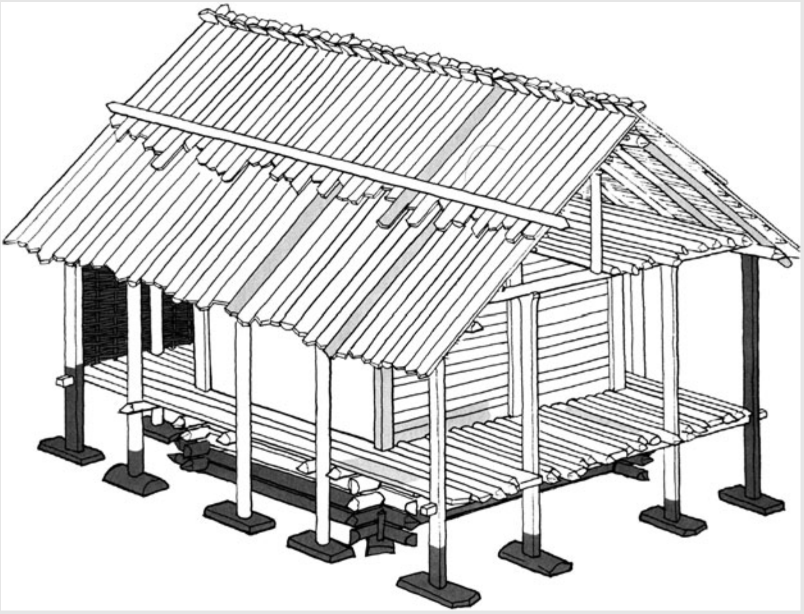


Fig. 4.6. Schematic reconstruction of the Late Bronze Age house of Greifensee-Böschen, Lake Greifen, Switzerland. (Courtesy of Kantonsarchäologie Zürich, Switzerland)

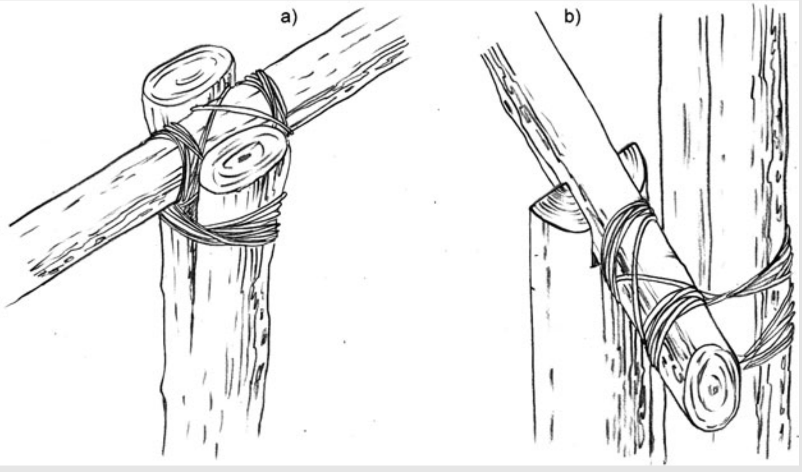


Fig. 4.7. The twin-pile building technique: a) long piles supporting the roof, and b) short piles supporting the elevated floor. (*Drawings*: Olenka Dmytryk)

continues

Box 4.1 Continued

Different species of wood were used according to specific needs and/or availability. For example, where possible, oak was used for large piles and cross-beams, whereas the type of roundwood used for walls and floors varied significantly, including birch, pine, maple, poplar, hazel, and other species. An interesting combination of two different species of wood for two different functions is the twin-pile technique (Fig. 4.7), whereby one long pile carries the weight of the roof, and the other the weight of the floor.

Such examples are found, for instance, at Hornstaad-Hörnle 1A (roof: alder/ash; floor: oak) (Dieckmann et al., 2006) and at Arbon-Bleiche 3 (roof: silver fir; floor: ash) (Jacomet et al., 2004). A further technique to elevate the house floor is the *Stelzbau* technique. In this case, vertically placed planks are perforated at a chosen height and horizontal piles slipped through. The top one supports the floor and the bottom one stabilizes the house, preventing it from sinking into the soft turf (Fig. 4.8).

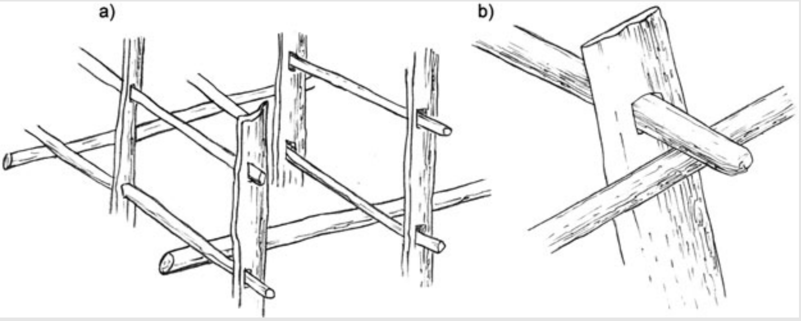


Fig. 4.8. The *Stelzbau* building technique. (*Drawings*: Olenka Dmytryk)

Dendrochronology studies have shown a constant repairing of the houses throughout their lives, which lasted for between ten and twenty years up to 3500 BC, increasing to several decades in later periods (Billamboz, 2006; Billamboz and Köninger, 2008). Exceptions that prove the rule do also exist: there is evidence that at the Late Neolithic (2786–2673 BC) settlement of Saint-Blaise/Bains (Lake Neuchâtel, Switzerland) a house was repaired and modified continuously for over one hundred years (Gassmann, 2007).

Residential and Special Purpose Houses

The majority of houses within the Circum-Alpine region lake-dwelling tradition were residential units, in which, however, various activities were carried out. Small houses usually consisted of a single room, whereas in larger ones (e.g. on Lake Feder, Germany) the internal space was divided

into two or more areas. Fireplaces and/or ovens were present in almost all houses, but sometimes they were also located outside, in front of the house. Small storage buildings have also been identified, but, except for Pestenacker (Schönfeld, 1992, 2009) the existence of stables and workshops has, as yet, not been proved (Ebersbach, 2002). No elite houses have yet to be identified within the Circum-Alpine region lake-dwellings. However, because of their unusual architecture, location, and artefact distribution, some constructions could be regarded as cult houses (Schlichtherle, 2006*b*) (see 'Ritual Architectural Structures', below). Despite the evident lack of hierarchical division in the lake-dwelling society and the multifunctional aspect of each residential unit, specific specialization in food and/or artefact production within the various houses can still be discerned (see e.g. Arbon-Bleiche 3, Ch. 6).

Outside the Circum-Alpine region, Neolithic and Bronze Age remains of waterlogged wetland houses are fairly scarce. Small rectangular pile-dwellings were constructed at Dipilio (Greece) in the second half of the sixth millennium cal BC (Hourmouziades, 1996), whereas the majority of houses of the almost contemporaneous lacustrine settlements of La Marmotta (Lake Bracciano, central Italy) (Fugazzola Delpino, 1998; Fugazzola Delpino and Mineo, 1995; Fugazzola Delpino and Pessina, 1999) and La Draga (Lake Banyoles, Catalonia, Spain) (Bosch et al., 2006; Tarrús, 2008) seem to have been built directly on the ground. Excellent evidence of Late Neolithic (2830–2770 cal BC) wetland houses comes from Hunte 1 on Lake Dümmer (central Germany), where three types of architecture can be distinguished in chronological order. The first and the oldest type consists of a peculiar polygonal hut (Fig. 4.9), measuring 3–3.4 × 5–5.5 metres, whereas the second and third types are one- or two-roomed rectangular buildings varying in size, from 3–4.4 × 4–7.5 metres (second type), to 3–4.5 × 4.8–11.3 metres (third type). The only substantial difference between the latter two types is the porch-like structure on the eastern side of the houses of type three. Types one and two seem to have been built directly on the ground, whereas type three, according to Reinerth, could have had slightly elevated (on stilts) floors (Kossian, 2007).

Evidence of wetland houses in other parts of the world, contemporaneous with the European Neolithic and Bronze Age periods, is not abundant. The remains of elongated pile-dwellings have been found at Humudu and Majiabang (*c.*5000–3800 cal BC) in China (Chang, 1986; Zhao and Wu, 1986–7), or the Jomon rectangular (5 × 10 metres) house of Ondashi (*c.*4000 cal BC) in Japan, which, interestingly, differs from the typical Jomon sunken-floor house of the same period (Matsui, 1992).

Fig. 4.9. Reconstruction of the polygon shaped Neolithic hut of Hunte 1, Lake Dümmer, Germany. (*Photograph*: courtesy of Gunter Schöbel, Pfahlbaumuseum, Unteruhldingen, Germany)

Returning to Europe, towards the end of prehistoric times (e.g. Iron Age), people's relationship with the wetlands (especially concerning inhabiting them) changed quite substantially, and in some cases even drastically. For instance, while in the Circum-Alpine region lacustrine settlements disappeared completely at the very beginning of the Iron Age, in other parts of Europe (e.g. the Baltic Sea regions and British Isles), they started to develop and reach their climax during this period and even later. Typical examples are the Scottish and Irish crannogs (see Box 4.2) and the lake settlements of the Masurian, Pomerania, and Wielkopolska regions in Poland. Although wetland house remains in Poland are not numerous, a fairly clear distinction in terms of house architecture can, however, be made between the three regions. While in the Wielkopolska region a prevalence of vertical pile constructions is noted, in the other two regions (Masurian and Pomerania) houses seem to have been built on large platforms (not on stilts) constructed on top of artificially built islands in the water near the lake shore. Two different ways of preparing the ground for constructing the houses have been identified: (*a*) the *Fascinenbau*, whereby the area is prepared with irregular timber and brushwood, and (*b*) the

Packwerkbau type consisting of different strata of roundwood to construct a large platform on top of which houses are subsequently built. The houses were mainly rectangular and quite limited in size (3.2 × 3.5 metres), as the ones found at Moltajny (Pydyn, 2007: 325–7). In the British Isles, apart from the crannogs, it is indeed in the Iron Age that the first proper wetland village, namely Glastonbury, was built (see below). Here, contrary to continental Europe, the shape of the houses was circular, reflecting that of typical Iron Age dryland houses and crannogs. The dwellings were between 5 and 8 metres in diameter and did not have a central post to support the roof. The entrance was between 1.4 and 2.1 metres wide, and the walls were made of wattle work and/or woven rods subsequently plastered with daub. The roof was probably thatched, while the floor was made of parallel-laid round timbers covered with clay. Traces of hearths raised above the floor were usually located in the central area of the hut, along with raised surfaces, possibly used as tables (Bulleid and Gray, 1917; Coles and Coles, 1996; Coles et al., 1992; Coles and Minnitt, 1995). Apart from the typical dryland round houses (e.g. Cat's Water) found in the elevated areas of the Fenland (eastern England), other examples of wetland habitations have been identified only in estuary environments, with the best known being the rectangular houses of Goldcliff in the Severn estuary. The seven (possibly eight—Martin Bell, pers. comm. 2010) identified buildings measured between 4.8 and 8.4 metres long, and 4.2 and 6 metres wide, and have characteristic rounded corners. One of the houses has two internal partitions, which are probably the remains of small animal stalls (Bell, 1999: 20). Similar buildings, dating from the Bronze Age, were also found at Redwick (5 km west of Goldcliff), whereas circular ones have been located at Chaper Tump (3 km west of Redwick) and Brean Down (Bell, 1999, 2001). In continental Europe, in addition to the three above-mentioned Polish regions, remains of waterlogged Iron Age houses are mainly located in the Netherlands and northern Germany. Two of the best examples are the Dutch Site Q in the Assendelver Polders, and the German Feddersen Wierde. The single building of Site Q measures 18 × 6 metres and dates from about the eight century cal BC. The house was roughly divided, two-thirds for cattle and one-third living space for people. It is interesting to note that two different species of wood were used for the two distinct areas; while alder was used for wattle walls for both people and animals, for some reason willow wattles were only used for people's quarters (Brandt and van der Leeuw, 1987; Coles and Coles, 1989; Therkorn et al., 1984). Similar house structures are also found at Feddersen Wierde, where a series of farmsteads were constructed on elevated ground above the floodwater in a coastal-marshland environment (see 'Settlements and Simple Agglomerations of Houses', below). As in Site Q, here the buildings were also divided into a long section for the domestic animals and short ones for people. The size of the houses varied from 10 to 20 metres long and 6 metres wide. There were also small residential units and workshops with no

animal stalls inside. The houses were built directly on the artificially elevated ground, had fairly solid wooden frames, possibly thatched roofs, and wattle work was used for internal partitions as well as external walls (Haarnagel, 1977; P. Schmid, 2002). This type of house, but even longer, was also found at the roughly contemporary site of Flögeln, situated inland on a large sandy area within a peatbog environment.

As briefly mentioned above, the last part of prehistory in Europe (Iron Age) was characterized by a peculiar division, in terms of people–wetlands interaction, between the Circum-Alpine region and the rest of Europe (including the Mediterranean). Contrary to a complete absence of wetland settlements (and houses) in the Alpine region and surroundings, elsewhere people continued to live within or very close to the wetlands. Major engineering deeds to adapt to the wet environment were carried out not only in the north, but also in the Mediterranean area. One of the best examples is the Poggiomarino settlement on the bank of the River Sarno (central Italy), where a series of artificial islets with houses and/or other buildings on top was constructed in a marshy riverine environment. The islets were oval, but the huts constructed on them were of rectangular shape (possibly with an apsidal end) constructed directly on the ground. In general the houses were fairly small (3–3.5 × 10–12 metres), although one seems to be more elongated than the others, and probably belonged to an extended family (Castaldo et al., 2008; Cicirelli and Albore Livadie, 2008; Pruneti, 2002).

North of the Alps, one of the largest and most compact agglomerates of Iron Age houses is the fortified lacustrine settlement of Biskupin in Poland (see below). The terrace houses were all lined up along the various streets and alleys, were all built using the block-building technique, measured on average 8 × 9 metres and had a single room where the bed was placed in the corner. The various domestic activities were carried out in the central area, next to a stone-built hearth. Each house had an entrance hall, which could have also served as animal shelter, whereas the upper (attic-like) level could have been either for storage, or sleeping (Coles and Coles, 1989, 1996; Niewiarowski et al., 1992).

Finally, the remains of an Iron Age lacustrine house have also been identified near the French Atlantic coast, and more precisely at Put Blanc, on Lake Sanguinet. The structure, which dates to the seventh or eighth century cal BC, measures 4.6 × 3.3 metres, was built directly on the ground and had a centrally located fireplace (Maurin, 2006).

In continental Europe Early Medieval and Medieval fortifications within wetlands are rare, and they are mostly located in the eastern regions of the Baltic Sea (note though that in some of these regions, the first millennium AD was still regarded as Late Iron Age—see Ch. 2 and Fig. 2.1) . One of the best known of such sites is Āraiši (ninth–tenth centuries AD) in northern Latvia (Apals, 1965), where amongst the 146 buildings (all constructed during the five occupational phases of the settlement), 76 were residential dwellings. The

Box 4.2 Crannogs Building Tradition: Scottish and Irish Crannogs

Scottish Crannogs

According to Morrison (1985: 16–20) a crannog has two prime characteristics: (*a*) it was intentionally used as an island (as opposed to lakeside dwelling); (*b*) it should be (at least partly) artificial. Because of these typical features, island duns have never been considered together with crannogs. Recent studies have, however, proved that the distinction between the two characteristics is ephemeral, difficult to detect, and maybe not as important as previously thought (Harding, 2004; Henderson, 2009). It is generally agreed though that the majority of crannogs were, or became later, *Packwerk* mounds, whereby organic material such as brushwood, turf, and peat (sometimes even stones) had been piled up into shallow water (mostly on top of an already existing submerged or semi-submerged island) and held in place by vertically driven piles (Cavers, 2007). The dwelling structure(s) (usually one or two houses) were then constructed on top of it (Fig. 4.10).

The size of a crannog varies significantly. For instance, out of eighteen crannogs on Loch Tay, three size categories have been distinguished: large (larger than 40 metres in diameter); medium (larger than 20 metres in diameter); and small (up to 20 metres in diameter) (N. Dixon, 2007). The tendency of a crannog to be occupied several times makes it difficult to identify the house structures and their shape; it is, however, believed that the circular dwelling did prevail through time. The only convincing evidence of *in situ* domestic structures on a crannog comes from Buiston crannog, where two round houses measuring 5.6 and 8 metres in diameter, and dating from the sixth–seventh centuries cal BC have been recorded (Crone, 2000).

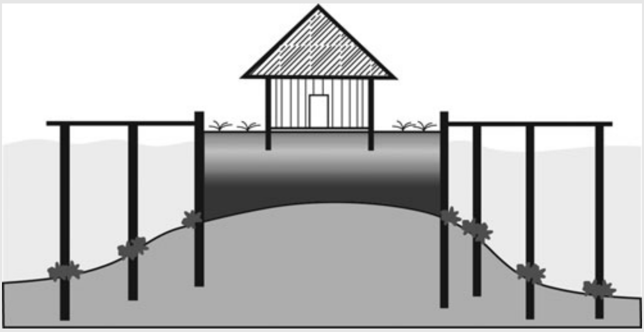


Fig. 4.10. Schematic reconstruction of a *Packwerk* crannog, showing the retaining walls of the artificial island on top of which is constructed the house. (*Drawing*: Ben Jennings)

The number of crannogs officially recorded in the National Monuments Record is 370 (Henderson, 2009: 39), but it is believed that it could be as high as 500 (N. Dixon, 2007: 253). Although crannog chronology spans

continues

Box 4.2 Continued

from the Neolithic to the seventeenth century, the highest number of crannogs is concentrated in the first millennium cal BC.

Not all crannogs are the same. They can be divided into various groups, whose geographical distribution throughout Scotland is chronologically significant. According to Henderson (1998*a*) there are five distinct types of crannogs: Highland, south-western, inter-tidal, Hebridean, and historic. Henderson argues that each of these types is linked to a particular geographical area and occurs during specific times. For instance, while the south-western type is restricted to the Solway-Clyde province, the Highland one is mainly located in central and northern Scotland; both types are mainly (but not always) prehistoric. On the other hand, the Hebridean type is a distinct form on the islands, but it can occur at the same time with Highland and historic types. Interestingly enough, crannogs are very scarce (if not completely absent) in the eastern and north-eastern part of the country.

Irish Crannogs

The main development of Irish crannogs occurs at later dates than those in Scotland, beginning from the sixth century AD. There are various theories concerning the origins of Irish crannogs. Some scholars argue for social and political upheaval and economic crises caused by climate change, which led to a destabilization of Irish society, triggering the development of fortified units such as crannogs. The location (west coast) of the first millennium BC Scottish crannogs has induced other scholars to believe that they (crannogs) have been introduced in Ireland by returning Irish emigrants from Scotland (Crone, 1993; Warner, 1983).

The structure and architecture of Irish crannogs remains unclear, for only a few houses have been identified. Possible house layouts were spotted at Lagore (seventh–eleventh centuries AD) (H. O. Hencken, 1950) and Ballinderry crannog 1 (tenth-eleventh centuries AD) (Hencken, 1936), but the only certain structure is that of Moynagh Lough (occupied several times from the Bronze Age to the Medieval period) (J. Bradley, 1991). Here four round houses have been identified: two from the Bronze Age (6 and 6.8 metres in diameter) and two from the Medieval period (11.2 and 5.2 metres in diameter). Instead of two houses built next to one another, some crannogs may even have had one large house that covered the entire crannog area, as was the case with the Scottish crannog of Milton Loch, or Oakbank crannog on Loch Tay (N. Dixon, 2004; Warner, 1994).

Irish crannogs continued to be occupied throughout the Medieval (*c.*1100–1350) and Late Medieval (*c.*1350–1534) periods, and in some cases became permanent lordly residences, after being transformed into inaccessible fortifications (O'Sullivan, 1998).

houses were all built with the block-construction technique and had gabled roofs made of wooden shingles. A similar settlement is found on Lake Valgjärv in Estonia. Here, despite the large number of massive (9 metres long and 30 cm in diameter) vertical and horizontal piles, no proper structures of residential units have been identified. Although these sites are regarded as fortified settlements, neither of them shows characteristic features of proper fortifications (e.g. palisades), apart from the natural setting (they were surrounded by water) (Roio, 2007: 31). A large square structure known as the Bulverket, also regarded as being a fortified settlement, was found on Lake Tingstäde Träsk on Gotland Island, Sweden. The structure, measuring about 170 × 170 metres and dating *c.*AD 1000–1200, consists of four rectangular wooden platforms arranged one after the other to form a large square platform with an empty space in the centre. Residential units were probably placed on top of the platform, which itself was surrounded by a massive palisade (L. Larsson, 1998). Unfortified Medieval residential units built within a wetland context in continental Europe are extremely rare. One of the best-studied examples is Charavives-Colletière (*c.*AD 1003–1040) on Lake Paladru, France. The site (surrounded by a wooden palisade) consists of three main buildings (partially attached to one another) and a few sheds and workshops. The largest building was the one in the middle and it is believed that its roof was as high as 14 metres (Colardelle and Verdel, 1993; Coles and Coles, 1996).

Evidence of waterlogged wetland house structures outside Europe in the past two millennia is not abundant. One area where this evidence is particular rich is the North Island of New Zealand. Here the best-preserved waterlogged remains of Maori houses come from the swamp settlements called *pa* (see Ch. 2, and Box 4.5 below). Although plans and layouts of Maori houses are often discovered in dryland sites, and isolated parts of the superstructure of houses do occur in waterlogged environments, a combination of the two (layout and superstructure) is rarely found. The only two examples of living floors and house superstructure components found together are those of Mangakavare 2 on Lake Mangakavare (Bellwood, 1978), and Kohika in the Bay of Plenty (Irwin, 2004*b*, 2005). Amongst the two, Kohika offers more detailed evidence of the different types of house architecture as well as the organization of the settlement. Two types of building can be distinguished at Kohika: the residential dwellings (*whare*) and storage buildings (*pataka*).

The *whare* architecture is itself divided into two types: the dressed-plank lashing technique, and the plain pole and thatch technique. The first type consists of a series of finely dressed planks with mortise and tenon joints carefully lashed together with fibre ropes (Fig. 4.11).

A remarkable characteristic of this type of construction is that, thanks to a series of face and edge eyelets carved into the planks, the lashing is mainly exposed only on the outside of the house frame, and therefore not visible from inside the house (Fig. 4.12).

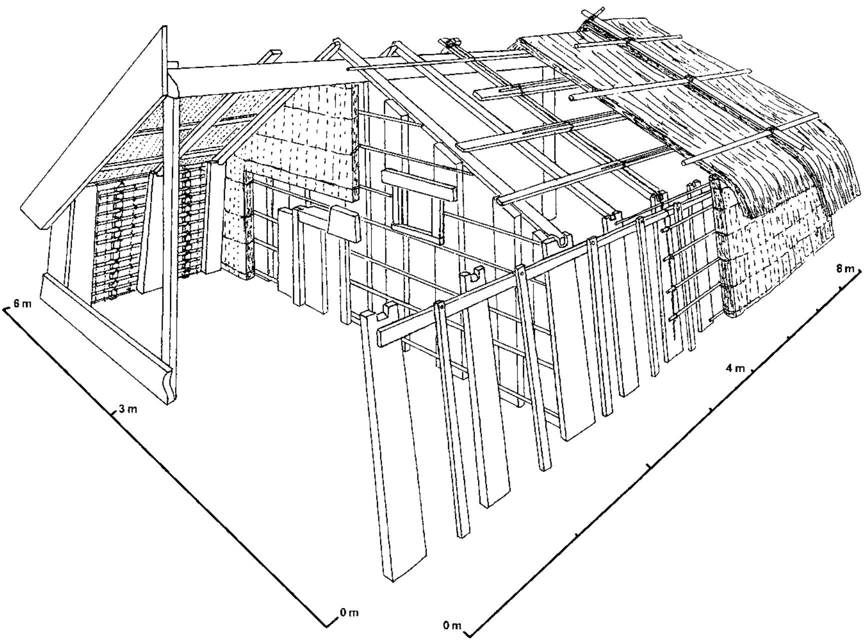


Fig. 4.11. Schematic reconstruction of the Kohika *pa* plank-dressed *whare* from the HS area, New Zealand. (Courtesy of Geoffrey Irwin, University of Auckland, New Zealand)

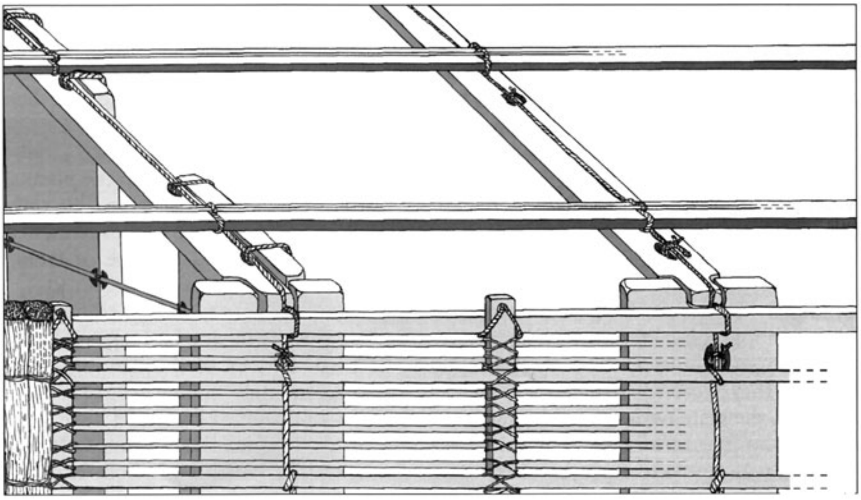


Fig. 4.12. Details of the external framing of the Kohika *pa* plank-dressed *whare*, New Zealand. (Courtesy of Geoffrey Irwin, University of Auckland, New Zealand)

Fig. 4.13. Elaborately carved door lintel (*pare*) of the Kohika *pa* plank-dressed *whare* from HS area, New Zealand. (Courtesy of Geoffrey Irwin, University of Auckland, New Zealand)

It has been suggested that this technique derives from the early Maori way of building canoes, whereby lashes were not exposed to the outside of the watercraft to avoid abrasion during landing. This perpetuation of carpentry techniques is in accordance with the Maori's conservative cultural aspect of house-building traditions (Prickett, 1982). Elaborately carved door lintels (*pare*) (Fig. 4.13) were also used to decorate the entrance of this type of house.

The second type of *whare* was built using undressed poles with joints lashed together where elements are crossed (in this case the lashing is visible from the inside). Despite the less elaborate way of constructing this type of house, the size of the building does not vary substantially from the more sophisticated type; on average, the Kohika houses are 3–3.65 metres wide, 4.50–5.40 metres long, and 2–2.3 metres high. However, the 'Yellow House' found in area D is larger: 5.35 × 7.24, reaching 2.85 metres at the ridge-pole (R. T. Wallace et al., 2004: 123). Walls and roofs of the Kohika houses were thatched with bulrush raupo (*Typha augustifolia*), a wetland plant very common in the region.

Storage houses (*pataka*) were also found at Kohika. The walls of a *pataka* were made of wooden planks simply lashed together, the floor was elevated and was reachable by a ladder with notched steps (Fig. 4.14).

The *pataka* were usually smaller than the *whare*, measuring 2.6 × 3.9 metres (R. T. Wallace et al., 2004: 123–5). The crucial importance of the Kohika houses lies in the fact that they allow us to link ethnographic descriptions of post-European contact house construction techniques to the less familiar traditions of the pre-European contact.

Outside New Zealand, waterlogged house remains are very limited. The best-known example is that of Ozette on the Northwest Coast of the United States. Here eight houses, measuring 21 × 11.5 metres and dating from the fifteenth to the sixteenth century AD, were found under a mudslide that sealed the Native

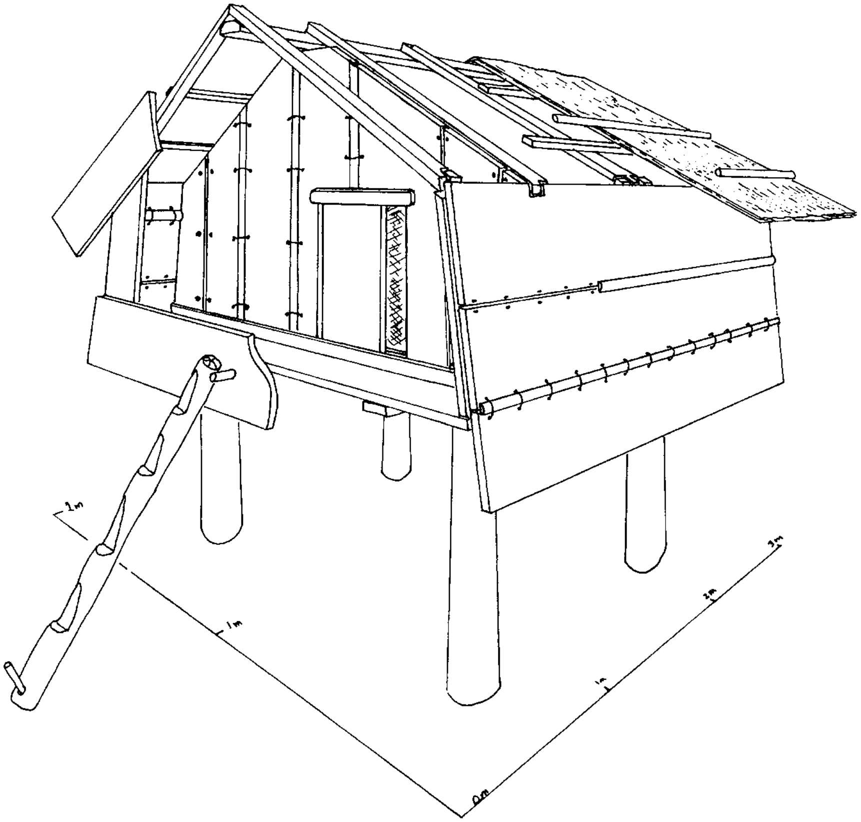


Fig. 4.14. Schematic reconstruction of the Kohika *pa pakata* from area D, New Zealand. (Courtesy of Geoffrey Irwin, University of Auckland, New Zealand)

American settlement while it was still occupied. Because of the sudden and unexpected calamity the buildings were sealed in a Pompeii-like way, and the structures remained perfectly preserved. Hence, parts of the superstructures of the buildings, such as plank walls, posts, and roofing, were still perfectly identifiable at the time of the discovery.

Finally, two totally different house structures were identified at Los Buchillones, Cuba. One house (^{14}C dated between the fifteenth and the seventeenth centuries AD) is of circular shape, the king posts are believed to have been as high as 7 metres, and, according to the thin vertical sticks that delineate the perimeter, the house should have had a diameter of 26 metres. Not far from this structure, there was a rectangular house (14 metres long), possibly bearing a two-slope gabled roof. Both houses (circular and rectangular) are believed to have stood on piles in shallow water (e.g. a lagoon), but in a place protected from the intense wave action of the sea (Pendergast et al., 2001, 2002).

Settlements and Simple Agglomerations of Houses

No matter how well preserved and thoroughly described individual houses are, they are not entities that can be understood on their own. Houses are in fact part of larger residential units such as settlements. The layout of buildings as well as the space between them reflects the way inhabitants interact with each other, and the environment. As a result, plan and size of villages may depend on a variety of factors, from land availability to cultural aspects, including intra- as well as inter-village relationships. For instance, an agglomerate of houses tightly clustered together does not always imply higher interaction and/or intimacy with the next-door neighbours. It rather depends on how easy it is to enter the building and/or the village (e.g. the distance between entrances, the presence of fences, the locations of communal space, and the size of both the village and the single dwellings). The concept of interactional distance is therefore germane to the study of both houses and settlements.

Due to the fact that the majority of settlements excavated in an archaeological context (especially concerning prehistory) are incomplete (this may depend upon a myriad of factors, such as size of the excavated area and preservation), analyses related to the use of space between and within the inhabited area become significantly limited, and in some cases, highly speculative (see Box 4.3). For instance, is it true, as is usually assumed, that the cycle of spatial arrangement (from lack of patterns to spatial order) breaks down after continuous rebuilding within a settlement, resulting in the failure of the community as whole (Fletcher, 1984, 1995)? Or, does the disposition of buildings play a crucial role in terms of settlement protection, or is the presence of fences and ramparts more important? With optimal availability of data, such as in Hornstaad-Hörnle 1 (Dieckmann et al., 2006), it may be possible to tackle the first question, or even to answer the second, if one deals with the Tripolye Culture riverine giant-settlements in Ukraine (Korvin-Piotrovskiy and Menotti, 2008). With the majority of cases though, especially with a limited excavated area in a wetland context, the available data is rather scarce.

When dealing with wetland settlements in Europe, three important factors have to be taken into account: period of occupation, geographical area, and type of settlement. For instance, Neolithic and Bronze Age settlements in northern Europe and Scandinavia differ considerably from those in the Circum-Alpine region. Not only are houses architecturally diverse, but also size, degree of agglomeration, and dispersion are different. In general, settlements tend to be more clustered in the Circum-Alpine region, as opposed to a more dispersed layout in the north. Moreover, the majority of wetland settlements in the north are not really constructed on wet ground, but on naturally elevated sandy areas, and this, of course, influences the site formation process, and consequently their preservation. It is therefore important to point out that

although the large majority of those settlements can be considered wetland settlements, virtually none of them has waterlogged remains.

Typical northern European prehistoric villages (often farmsteads) consist of a main farmhouse and number of outbuildings (maybe even other small houses, granaries, and/or haylofts). In some cases, for instance, the Neolithic settlement of Bejsebakken (northern Denmark), the village consisted of twenty-three houses clustered within three to four areas (Sarauw, 2008). Characteristic of prehistoric Scandinavian settlements is the reflection of long-term occupations of a given territory, with repeated rebuilding of houses (or farmsteads) within that area. The shifting from an old to a new place usually occurs every two or three generations. An example of such settlements is the Bronze Age site of Bjerg (west Jutland) (Olausson, 1992; Rasmussen and Adamsen, 1993). Various such settlements are also found at Bjerre (northern Denmark). Here, the nineteen identified sites span a period of time of about a thousand years, but only one or two farmsteads were contemporaneous (Bech, 1997, 2003). A similar situation is found in the Low Countries (the Netherlands), where settlements were also built within wetland environments, such as coastal dunes areas, inland peat areas and river floodplains, but preferably on levees and/or *donken* (Arnoldussen, 2008*b*; Arnoldussen and Fokkens, 2008; Louwe Kooijmans, 1993).

On the British Isles, apart from the Irish and Scottish crannogs, the settlement location (on slightly elevated areas within the wetlands) also reflects that of northern Europe, with the only difference being the house architecture and shape (round instead of rectangular—see 'Houses in Wetland Contexts' above, Ch. 2, and Boxes 4.1 and 4.2). Significant waterlogged settlement remains are more abundant in central Europe and the Mediterranean. Although the best evidence comes from the Circum-Alpine region (see Box 4.3), other areas such as central Germany, Greece, central Italy, and eastern Spain have also yielded important traces of wetland settlements. Sites such as Dispilio (Greece), La Marmotta (central Italy), and La Draga (Catalonia, Spain), have not only shed light on the very first lacustrine house architecture, but they have also contributed to trace the possible origins of the Circum-Alpine region lake-dwelling tradition (see also Ch. 2). As often happens with wetland excavations though, the limited extension of the excavated area has prevented archaeologists from identifying the full extent (perimeter) of the villages. A somewhat luckier situation occurred at Hunte 1, on Lake Dümmer (central Germany), where a full perimeter of a Neolithic wetland settlement consisting of twenty-four houses built with two distinct phases was identified in 1934 (Kossian, 2007) (see also 'Houses in Wetland Contexts' above, and Ch. 2). A few such lacustrine villages, dating from the Neolithic to the very end of the Bronze Age, have also been found in the Circum-Alpine region (see Box 4.3). Despite the active people–wetlands interaction, evidence of proper Neolithic and Bronze Age settlements in the north-eastern regions of the Baltic Sea is

Box 4.3 Central Europe's Circum-Alpine Region Lake-Dwelling Tradition

The Circum-Alpine region lacustrine settlements are the result of a particular lake-dwelling tradition with possible Mediterranean origins dating back to the sixth millennium cal BC. The tradition gradually expanded northwards, becoming established around the major Alpine region lakes around the end of the fifth millennium BC. From then, the tradition perpetuated itself throughout the Neolithic and the Bronze Age, until it suddenly came to an end at the very beginning of the Iron Age. The 3500-year-long lakeside occupation was not by any means homogenous; settling phases alternated with phases of abandonment. This discontinuity did not follow specific patterns but varied according to place and time. Some hiatuses were caused by environmental factors (e.g. that of the Middle Bronze Age) (Magny, 2004*b*; Menotti, 2001*a*, 2003), others were purely cultural (e.g. the Bell Beaker period). A combination of both factors, though, is often the most plausible explanation.

Size and Morphology

Although there was a tendency to build larger and more permanent settlements from the beginning of the third millennium BC, size variation did not seem to follow specific chronological or geographical patterns. Identifying size and layout of the lacustrine settlements is not always easy. Due to the often limited extension of wetland excavations, the full size of a settlement is seldom known. In some cases (especially with large settlements), test trenches and educated guesses are used to work out the extension of the village and house plans (e.g. Sipplingen-Osthafen, Lake Constance). The results can, however, be misleading: size can be under- or overestimated and house plans and orientation misinterpreted (see e.g. Hornstaad-Hörnle 1A). Excavations of entire villages have, however, been possible, and as a result we can now distinguish three broad divisions: small settlements (<15 houses), medium (15–40 houses) and large (>40 houses). To mention but some examples, small settlements have been identified at Seeberg, Lake Burgäschi, Switzerland (6 houses) (Wyss, 1990); Dullenried and Seekirch-Stockwiesen, Lake Feder, Germany (6 and 11 houses) (Schlichtherle, 2004); medium ones at Sutz-Lattrigen-Kleine Station, Lake Biel, Switzerland (18 houses) (Hafner and Suter, 2000) and Hornstaad-Hörnle 1A, Lake Constance, Germany (25 houses) (Dieckmann et al., 2006); and large villages at Sutz-Lattrigen-Hauptstation (thirty-second century BC), Lake Biel (>70 houses), and ZH-Mozartstrasse (layer 3, thirty-second century BC), Lake Zurich (>50 houses) (Schibler et al., 1997*b*).

continues

Box 4.3 Continued

Although most villages were thoroughly planned (e.g. with a central street and houses clustered around it), the orientation of the houses (e.g. the long side of the house being parallel/perpendicular to the lake shore) does not seem to have followed any specific chronological or geographical rules. There is the possibility, however, that some characteristics, such as the main street being perpendicular to the shore, developed in the central part of the Circum-Alpine region towards the end of the fourth millennium BC, and subsequently expanded westwards (Pétrequin et al., 2006*a*).

Occupational Patterns and Territoriality

Despite the fact that the vast majority of lacustrine villages (if not all) were permanent residential units occupied all year around, their life biography was extremely dynamic. How they were planned, their development, and their final abandonment depended upon a myriad of factors (location, geographical distribution and density, availability of resources, and intra- and inter-village social relationships). Thanks to the remarkable dataset available (e.g. dendrochronology), one can often identify the life biography of a settlement, as well as specific settling patterns. The construction of some villages (e.g. Arbon-Bleiche 3 and Sutz-Lattrigen-Riedstation) started off, for instance, with one house, but the real construction 'boom' did not take place until the third or fourth year (Hafner and Suter, 2000; Jacomet et al., 2004) (see also Box 6.2). House remains often retain traces of fixing, enlargement, and in some cases even the drastic cause of abandonment (e.g. fire). The layout of the village (e.g. house disposition, streets, and communal space) also tells us a lot about planning and intra- or inter-settlement relationships between people. For instance, a settlement might not only be occupied and abandoned in different phases, but it might also be reoccupied several times. Systematic planning according to the *Hausplatz* concept is found in various lacustrine villages (Billamboz, 2006). A defined space, known as the *Hausplatz*, within the settlement, where domestic groups are expected to live, is planned in advance and people or groups joining the village 'must' build their houses in that particular area. There are examples of settlements being occupied (although through different phases) for a long period of time, and houses being rebuilt on the very same spot (see Hornstaad-Hörnle 1B). Whether the reconstruction of the house was done by people related to the previous group or household is more difficult to prove; the reconstruction may be the result of more complex factors linked to social memory (Borić, 2003, 2008, 2010; Whittle, 2010). There are, on the other hand, cases where the *Hausplatz* is used in a quite different way from that of the previous occupation. After being

completely destroyed by fire, the settlement of Sutz-Lattrigen-Rütte (2704 BC) was, for instance, reconstructed straight away (and in one go), but with the houses having a totally different orientation (from horizontal to perpendicular to the lake shore) (Hafner and Suter, 2004: 23).

The study of interrelationships between villages, and the use of off-site land between settlements, has led to the developments of the *Siedlungskammer* concept (Billamboz, 2006; Krahn, 2006; Zimmermann et al., 2004). The term *Siedlungskammer* means a given area encompassing one or more settlements and their immediate surroundings. This area (which includes forest and agricultural land) can be either contested or shared by local groups (or villages). Spatial analyses of Neolithic settlements (e.g. ZH-Seefeld (layer E–D, 2719–1289 BC) and ZH-Mythenschloss (layer 2.2–2.4, 1724–2703 BC) and their distribution in relation to demography, land use, and economy in the Zurich bay (Lake Zurich) have, for instance, identified exploited areas too large to be managed by a single group or settlement. Hence, the idea of territories shared by two or more communities (not only lakeside settlements) seems more plausible (Ebersbach, 2003; Gross-Klee, 1997). This cooperation (or, possibly, lack of it) between groups would affect not only the economy but also occupational patterns linked to local or regional migrations or simply settlement shifts. One of the best examples of diachronic change in lake-shore occupation in a given area is found at Auvernier and surroundings (Lake Neuchâtel), between the thirty-eighth and the twenty-fifth centuries BC. From a complete lack of contemporaneity and a continuous shift back and forth of a single settlement, to two different locations (about 1 km apart) between the thirty-eighth and the thirty-sixth centuries BC. This period was then followed by four contemporaneous villages in the same area, during the twenty-eighth century BC, and finally, a return to a single occupation in the area, between the twenty-seventh and the fifteenth centuries BC (Stöckli et al., 1995).

Social Organization

In most cases, groups (or households) within a settlement were relatively autonomous; as long as they respected the settlement's rules (see the *Hausplatz* above), they were free to join or leave the community at any time (Ebersbach, 2010*a*). There has been debate as to whether a household was limited to a single building or expanded to others. At Saint–Blaise/Bains (Lake Neuchâtel) for instance, wood from the same tree trunk was used in different houses, whereas settlements such as ZH-Mozartstrasse, Sipplingen, and Arbon-Bleiche 3, yielded pottery with the same potter's signature distributed among various houses (though possibly the same

continues

Box 4.3 Continued

household). Despite the fact that all houses were autonomous in terms of food and goods production, the quantity varied from house to house, and in some cases different areas of a single village could be distinguished (see Arbon-Bleiche 3). There is also the possibility of multi-ethnic groups living in the same village. At Concise (Lake Neuchâtel), for instance, houses were constructed in the same way, but a fifty-fifty ratio of local (Cortaillod) to foreign pottery was identified (Burri, 2005, 2007). Similarly, in the Pfyn-Horgen lakeside village of Arbon-Bleiche 3, Boleráz pottery was produced alongside local, traditional pottery (de Capitani et al., 2002). Were Concise and Arbon-Bleiche 3 real multi-ethnic settlements, or were local people simply copying the pottery style of other cultures?

Finally, it is surprising that with such detailed archaeological data no (or very little) evidence of a stratified social organization has been identified. Was there really no hierarchical division within the lake-dwelling communities of the Circum-Alpine region, or was it simply so well hidden that it does not appear in the archaeological record? Maybe we are not looking for it with the correct tools.

rather scarce. However, traces of occupation and isolated dwellings have certainly been identified; whether or not they might have been part of systematically planned settlements is yet to be confirmed. It was not until the Iron Age that proper marshland and lacustrine villages started to be constructed. The majority of these agglomerates of dwellings were built on both natural and artificially enhanced islands or peninsulas, and were surrounded by a protective palisade. Some of them even developed into heavily fortified compact residential units, with sturdy ramparts and massive palisades (see Biskupin, above). Similar fortified villages, known as the *terramare*, developed in the Po Plain (northern Italy), from the Middle Bronze Age onwards (see Box 4.4).

The rest of Europe does not mirror the complete disappearance of wetland settlements in the Circum-Alpine region at the very beginning of the Iron Age. For instance in the British Isles not only is there a noticeable increase of Scottish crannogs, followed by the Irish wave later on (see Box 4.2), but also the establishment of the first proper wetland (lakeside) village: Glastonbury. Unlike other Bronze Age and Iron Age settlements built within wetland environments (but on dry soil), Glastonbury was constructed on wet terrain, with all the disadvantages (and of course advantages) that come with it (see 'Houses in Wetland Contexts', above). Old and more recent interpretations have triggered incandescent debates about the village layout, its inhabitants, and chronology (Bulleid and Gray, 1917; Coles and Coles, 1996;

Box 4.4 ***The Terramare***

Origins and Development

Contrary to what it may imply, the etymology of the term 'terramare' has nothing to do with the two natural elements: the earth/land (*terra*) and the sea (*mare*). But rather it is rooted in the deep Emilia region peasant tradition. 'Terramare' was the name given to the mounds of ammoniacal soil, a rich fertilizer, found scattered around the low Po Plain area (Bernabó Brea et al., 1997; Cavedoni, 1864). It was only after a few archaeological excavations of those mounds that it was realized that they were more than just fertilizer—they were the remains of an ancient Bronze Age settlement tradition of the northern Italian Po Plain. The origins of the *terramare* are believed to be linked to the northern Italian lake-dwelling tradition (the *Palafitte*), in the Early Bronze Age (Bronzo Antico, 2300–1650 cal BC). At this stage though, all the occupations were mainly located north of the Po River. It is not until the beginning of the Middle Bronze Age (Bronzo Medio, BM1, 1650–1550 cal BC) that the *terramare* began to be constructed south of the Po River, though still not in the Emilia region. The *terramare* construction boom took place from the BM2 (Bronzo Medio 2, 1550–1450 cal BC) onwards, reaching its peak between the BM3 (Bronzo Medio 3, 1450–1330 cal BC) and the Late Bronze Age (Bronzo Finale 1330–1170 cal BC) (Bernabó Brea et al., 1997: 25–9).

The Settlement Morphology

As Cremaschi (1997: 107) suggests, what remains of the *terramare* today is a series of mounds scattered around the lower Po Plain area, resembling the Tell occupations of the Middle East plains, the only difference being the type of dwellings constructed and the material used: wood rather than clay or mud. At the early stage of development, the *terramare* were, as Strobel called them, '*palafitte a secco*' (dryland pile-dwellings) (Strobel, 1874). In fact, the majority of the *terramare* at the early stage of their development were built on dry terrain and often surrounded by palisades or shallow moats (see Fig. 4.15).

Contrary to what was believed in the late nineteenth century, the construction of the embankment did not take place at the initial foundation of the settlement, but was added later. The construction of large embankments, with massive square wooden log-constructions filled with piles and debris to stabilize the rampart, is probably the result of a tendency (maybe a necessity) to build fortified villages towards the last phase of the *terramare*. Typical examples of these constructions are the massive wooden caissons of Castione dei Marchesi (see Fig. 4.16) (Pigorini, 1882–3), or the reinforced

continues

Box 4.4 Continued

Fig. 4.15. Chierici's 1884 drawing of a typical *terramare* at an early stage of development. (*Photograph*: Courtesy of the Musei Civici di Reggio Emilia, Italy)

embankment of the small *terramare* (there is also a large one) of S. Rosa di Poviglio (Bernabó Brea and Cremaschi, 1997). In some cases, a moat was built around the embankment and filled with water obtained from nearby rivers or creeks by means of artificial canalizations.

Socio-economic Aspects

The *terramare* were mainly farming communities whose economy was based on animal breeding and cereal cultivation. The most common domestic animals were sheep and goats, followed by pigs and cattle (De Grossi Mazzorin and Riedel, 1997). However, there are some areas, such as the regions north of the Po River, where cattle were predominant, and others, for instance the settlements of Poggio Rusco, where the percentage of pigs was fairly significant (Catalani, 1984). A large portion of available land was cultivated for cereals, mainly wheat, barley, and millet; evidence of peas and other legumes is rather scarce. Agricultural tools were quite simple and made of wood, animal bones, and antlers. Although not a single entire plough has ever been found within the *terramare*, some fragments of it imply that it was certainly used (Forni, 1997). Agricultural activity within the *terramare* was complemented by metalworking, pottery, and finely worked art and craft objects. Local and long-distance trade was an important part of the *terramare* economy.

The sociopolitical structure of the *terramare* communities was fairly egalitarian, with no substantial evidence of marked social stratification. People cooperated within an economic system focused on the single village or farming community (Cardarelli, 1997). In comparison to the large number of settlements, the cemeteries linked to the *terramare* are rather limited. They are, however, sufficient to state that the prevalent mortuary practice was cremation; the ashes were placed in pottery urns and buried on hilly terrains 200–250 metres from the settlements (Cardarelli and Tirabassi, 1997: 677).

The Decline

Identifying precisely what caused the decline of the five-century-long *terramare* tradition around 1200 cal BC is not an easy task. As pointed out above, the *terramare* went through different phases of development; from simple '*palafitte a secco*', to heavily protected villages. This shows that, despite the absence of a marked sociopolitical hierarchy, social change did certainly take place. Whether the influence was from outside or indeed

Fig. 4.16. Block-constructed wooden caissons of Castioni dei Marchesi, used as reinforcement for the embankment (After Pigorini, 1882–3)

within the community itself is not clear. Most scholars do, however, believe that the decline could be the result of a combination of factors. Slight change in climatic conditions, possibly linked to a drop in the water-table (Cremaschi et al., 2006), may have caused crop failures leading to an economic crisis. Fuelled by social instability and external pressure (the presence of massive fortifications), the *terramare* communities would no longer have been capable of sustaining the increased effort (cultivation, building maintenance, trade, etc.) required, and the (communal) system collapsed. Although some *terramare* (e.g. S. Rosa di Poviglio—large village) show evidence of a sudden and quick abandonment, the whole process was rather gradual; and in fact some settlements, such as Ca' de' Cessi, seem to have survived longer (de Marinis et al., 1994). What still remains a mystery is the total absence of any kind of settlement in the area for the following three centuries after the *terramare* disappeared.

Coles and Minnitt, 1995; Aalbersberg and Brown, 2010). It has eventually been agreed that the numerous circular mounds identified by Bulleid were not all occupied at the same time; in fact, some of them were not even dwellings. The village experienced a fairly rapid development, which can be divided into four phases. The early phase, starting at about 250 cal BC and lasting 25–30 years, consisted of only a few round huts (about four) surrounded by a slender fence. In the middle phase more houses were built (about ten in total), and the occupation lasted longer (50–60 years). The village maximum extent was reached in the late phase (*c.*100 cal BC), when about fifteen houses stood at the same time; the occupation was also the longest amongst the four phases (75–90 years). In the final phase, the settlement shrank to about five dwellings (all built on previously occupied locations) and they were occupied for only 25–30 years (maybe even seasonally). Glastonbury was eventually abandoned *c.*50 cal BC (Coles and Coles, 1996; Coles and Minnitt, 1995).

On mainland Europe, one of the best-preserved wetland villages, more or less occupied in the same period, is Feddersen Wierde (northern Germany) (Schmid and Schuster, 1999). Two main phases of occupation can be distinguished at this *Wurt*-settlement; one from the first century BC to the fifth century AD, and the second (after about 200 years of abandonment) starting in the Early Medieval period and ending around the thirteenth or fourteenth century. Eight to eleven farmsteads were first built on the elevated levee (*c.*6 ha) lying between two creeks, in the first century BC (56 BC—*terminus post quem*). Because of the rising sea level each farmstead was raised on its own *Terp* or *Wierde* (mound), but, by the third century AD, the various mounds eventually merged into one raised area, on which 39 buildings were erected. During this time, the houses were quite large (up to 20 metres long and 6 metres wide), but the size decreased soon afterwards, and, following a further sea-level rise, the settlement was finally abandoned in the fifth century AD (Haarnagel, 1977; P. Schmid, 2002; Schmid and Schuster, 1999). Similar processes of house-building space claimed from a wet environment also took place more than a thousand years earlier at Poggiomarino (central Italy), where a series of artificial islands were built within a marshy and riverine area and used as building grounds for houses and workshops. The navigable waterways around them facilitated the transport of goods, while cultivation and other agricultural activities were carried out on drier terrains nearby (Albore Livadie et al., 2005; Cicirelli and Albore Livadie, 2008).

Apart from the Irish lacustrine crannogs, wetland settlements started to disappear gradually from the early second millennium AD. The only known lakeside dwelling of the period in mainland Europe is Charavives-Colletière on Lake Paladru (France) (Colardelle and Verdel, 1993). More and more land for agricultural purposes was claimed from the wetland, and the inexorable destruction of settlements began, although in some regions they still played a crucial role in people's everyday lives.

Outside Europe evidence of structured settlements within wetland environments is scarce. Agglomerates of houses were certainly built within flooded areas in Neolithic China (see e.g. Tianluoshan and Hemudu, Ch. 2), as much as during the whole Jomon (e.g. Ondashi) or the Yayoi period (e.g. Toro) in Japan, but waterlogged remains of dwelling superstructures are considerably limited. However, as pointed out in Chapter 2, the paucity of fully identifiable settlement plans does not suggest a reduced interest in, or limited interaction with the wetland, as is shown by the rich archaeological evidence (although no dwelling structures) found in Florida, and the Northwest Coast of North America (Ch. 2). A totally different picture is offered by New Zealand, where favourable preservation conditions have frozen in time the importance of the wetlands for the past and present Maori people (see Box 4.5, and Ch. 2, under 'New Zealand').

Box 4.5 The Maori *Pa*

Pa are fortified Maori settlements usually located within swampy areas or on islands in shallow lakes. Although the majority of *pa* are built on naturally elevated ground in a wetland environment, some of them are constructed artificially in a way that resembles that of Scottish and Irish crannogs, as Reverend R. Taylor described in the eighteenth century (Coles and Coles, 1989: 150). Once the terrain was raised enough from the surrounding waters, houses were then constructed; the settlement was eventually enclosed and protected with a wooden palisade. A *pa* consisted of an agglomerate of residential houses (*whare*), amongst them one or more (depending on the size of the village) carved houses, in some cases even a parliament house (*whare whakairo*), and a few storage houses (*pataka*) (see 'Houses in Wetland Contexts', above). Recent interpretations have advanced the idea that, more than purely straightforward fortifications, *pa* were visual symbols of prestige and power. There are, however, examples such as one *pa* (MA 2) at Lake Mangakaware, where evidence of warfare was clearly visible. In fact, fragments of broken stone hand clubs, wooden spears, and even burnt human skull remains have been found between the double-row palisade of the village, confirming that a real battle must have taken place there at some stage (Bellwood, 1978).

The majority of swamp *pa* occur in the North Island and more precisely on the Hauraki and Rangitaiki floodplains, in the basin of the Waikato River, and on isolated lakes such as Lake Harowhenua and Lake Tutira. Some of the best researched *pa* are, for instance, those of Lake Mangakaware, Lake Ngaroto, the heavily fortified village of Oruarangi, near the

continues

Box 4.5 Continued

Waihou estuary, and the Kohika village (Irwin, 2004*b*, 2005) (see also Ch. 2, under 'New Zealand').

Despite their defensive character, the *pa* were not refuges hidden away and marginalized in secluded places such swamps and lakes, but rather strategic focal residential areas with, most of the time, a self-sufficient economy, which was nevertheless linked to exchange networks via the numerous waterways flowing from the hinterland to the coast. The diversity of building structures, as well as the richness of material culture found in some *pa*, show status differences and hierarchical structure within the community. Interestingly enough, this noticeable sociopolitical organization (rather than environmental threats) ultimately played a crucial role in their survival. Flooding and other adverse natural calamities did certainly influence the wellbeing of the *pa* inhabitants, but other more socially intricate reasons prevailed for people to decide to abandon their homes (see the Kohika case for instance).

Wetlands were also fairly often occupied in Australia, New Guinea, and the Americas in the past thousand years. However, especially concerning settlements, particular site formation processes have limited their preservation and they are therefore more difficult to find. Apart from Ozette on the Northwest Coast of the United States, and the Norse settlement of L'Anse aux Meadows, Newfoundland, Canada (see 'Houses in Wetland Contexts' above, and Ch. 2), traces of settlements in wetland contexts are limited to partial house structures, which may be difficult to identify as being part of proper villages (see Los Buchillones above). There are, of course, exceptions, and one of them is in the centre of Mexico City, where Late Aztec pyramids and other buildings overlie wooden remains of earlier communities, that used to build their settlements in the former lake basin. Unfortunately, we will never know the extent of those ancient wetland villages; they will probably remain buried under the city forever. Living within and being closely in touch with the wetlands was also part of the Aztec, Maya, Teotihuacan, and other Mesoamerican pre-Columbian cultures, which also used to build their settlements in wetland contexts. In some parts of the world living in the wetlands was not only a custom of the ancient past, but it perpetuated until very recently. In a few cases, these customs still continue today (see e.g. the reed houses near Puno, Lake Titikaka, Peru; the pile-dwellings of Ganvié, on Lake Nokoué in Benin (Africa); and of course the numerous indigenous groups occupying the vast wetlands of the Amazon Basin in South America).

CONTACT AND TRANSPORT

As is argued throughout the book (see in particular Chs. 2 and 8), wetland communities were not isolated entities living in secluded places and socially detached from the rest of the world, but were instead well-integrated groups linked together by complex socio-economic networks. Not only were wetland settlements in contact with those in drier areas, but they were often situated on crucial pivotal intersections of short- and long-distance trade routes. Their convenient location (e.g. on lake shores, river banks, or other navigable waterways) facilitated the transport of goods, hence increasing the chance of developing economically and becoming focal points of exchange.

Although archaeologically visible through artefact distribution, how and where goods travelled from one place to another is far more difficult to detect. Before (and after) the advent of long-distance roads with the Romans in Europe, the Maya in Mesoamerica and the Incas in South America, to mention but a few, the majority of traded goods travelled via water (this is, of course, not to say that before those civilizations no roads existed). Paths and minor roads on drylands have always been constructed, but the existence of them is, unfortunately, often not identifiable. Within the wetland environments (mostly peatland, marshland, and fens) on the other hand, anaerobic conditions have preserved a variety of wooden trackways built to explore, or simple cross those seemingly inaccessible areas (see below). The wetlands were also criss-crossed by navigable water channels and basins, within which different types of watercraft were used to transport people and goods. In both cases though, the wetlands still retain remarkable evidence of how our ancestors used to interact with and explore them.

Trade and Exchange

It is not the purpose of this section to identify or reconstruct major trade networks within and between wetland communities, or even to isolate what may be inappropriately called ‘wetland trade’. Instead, the wetlands (and wetland settlements) would be considered as facilitators (or maybe obstacles) within a broader trade and exchange network system. This will help identify the extent to which wetland people were engaged in this system, how they affected it, and finally how they were influenced by it. Although tightly interwoven, exchange networks are not all the same. In prehistoric Europe for instance, up to the Bronze Age (and in some areas even throughout the Iron Age), exotic goods were obtained via long-distance trade routes, which were nevertheless linked to short-distance down-the-line exchange networks used for subsistence goods.

Metal and amber were two of the most common materials, and underwent various phases of value and significance change throughout prehistory. Amber, for instance, used in the Scandinavian elite burials during the Mesolithic, became a commodity for export in the Bronze Age, when bronze, because of its rarity, was considered more prestigious. The exact opposite happened in central Europe and the Mediterranean, where the scarce amber was more appreciated than metal. Amber and metal were in this case both commodities and exotic materials, but in two different places. Evidence of this interesting switch of amber value from exotic item to commodity is clearly visible at the wetland settlements of Bjerre (Denmark), where large quantities of unworked amber (1800 pieces found at site 7) were collected and stored by local farmers for export (Bech, 1997, 2003; Earle, 2002). Local farmsteads were probably the first cog of a larger chain exchange system that would eventually have linked northern Europe to the south. A further example of wetland settlements facilitating short- and long-distance exchange systems are the Iron Age villages of Meare and Glastonbury. Both Meare villages (west and east) were important trade centres and both yielded evidence of glass beads produced locally and traded with neighbouring areas as well as with central Europe (Coles, 1987; Coles and Coles, 1986; Orme et al., 1983). It is even believed that the Glastonbury lake village (situated only 5 km away) developed as an offshoot in response to the successful trade centre of Meare (Coles and Coles, 1996). This, along with many examples within the Scottish and Irish crannog tradition, show that the majority of wetland settlements (prehistoric and historic) were certainly not isolated entities but were well integrated with local, regional, and interregional socio-economic networks.

On the other hand, an example of significant wetland settlements acting as obstacles on a long-distance trade route may be that of the Middle Bronze Age lacustrine villages of northern Italy. Finely worked amber beads covered with gold, travelling from the British Isles to south-eastern Europe are found in the northern Alpine region lakeside dwellings (e.g. ZH-Mozartstrasse), but not in those of northern Italy. Considering that links between the north and south of the Alps were already well established in the Neolithic (e.g. the flints from Monti Lessini found in various northern Alpine lake-dwellings) (Affolter, 2002; Hafner and Suter, 2000), as well as in the Late Bronze Age/Iron Age (e.g. the glass beads from Frattesina, Veneto region, to Hauterive-Champréveyres, Lake Neuchâtel) (Bellintani and Stefan, 2009; Rycyhner Faraggi, 1993), it is more likely that the avoidance of that particular traded item by the Italian lake villages was intentional, and probably not linked to specific trade networks. The Alps as a natural barrier, as argued by some scholars, may not apply in this case.

An interesting combination of short- and long-distance trade networks is that of the Late Mesolithic and Neolithic (often perpetuating throughout the Bronze Age) eastern Baltic Sea regions, and north-western Russia. Here, in

addition to non-perishable materials (e.g. stone axes and flints), perishable ones such as seal fat and fur were traded down the line for relatively long distances (e.g. fur reaching the Middle Dniester River regions, mainly from the Belarus area, in exchange for grain and various other domesticates—especially during the latest phase of the Neolithic) (Zvelebil, 2006, 2008). These well-established connections eventually facilitated the adoption of agriculture and the establishment of wetland settlements (at first seasonal, then more permanent).

Although, as pointed out above, the purpose of this section is not to identify or reconstruct ancient trade routes, there are some wetland sites whose archaeological evidence is good enough to do so. For instance, the large amount of gravel, endemic to Sardinia and Ischia Island, found at Poggiomarino, has been interpreted as ballast placed in small boats (possibly dugouts) arriving empty from those two locations; the boats were then loaded with produce from the Sarno Plain, and sent back to Sardinia and Ischia Island (Cicirelli and Albore Livadie, 2008). Another good example is the identification of the Late Bronze Age Atlantic Complex sword trade network, stretching from Sardinia (Italy) to Spain and France, where the foremost exchange networks followed the major and minor watercourses up to the Atlantic and North Sea coasts and beyond (Cunliffe, 2001, Quilliec, 2001).

Ancient short- and long-distance trade involving wetland communities was, of course, not just a European phenomenon. Evidence of exotic goods traded along well-established networks is also found in China (especially in the Yangtze River Delta), Japan, Florida (e.g. Republic Grove), the Northwest Coast of North America (including Canada and Alaska), and New Zealand (mainly on the North Island), where inland water transport was particularly facilitated by the numerous swamps, rivers, small creeks, and shallow lakes (see e.g. the Bay of Plenty).

Within and Between the Wetlands: Trackways, Causeways, and 'Roads'

In the absence of navigable waterways, wetland environments such as peat-bogs can be treacherous places to cross. Yet, no matter how difficult it might have been, people always found a way to penetrate, explore, or simply cross them. The best evidence of this intense interaction is the numerous wooden trackways found within those bogs. In Europe, evidence of ancient trackways spans from the Neolithic to the Middle Ages and in some cases even much more recently. Trackways can potentially be found in any European bog, although in some areas, such as Ireland, the Somerset Levels (England), Lower Saxony, (Germany), the Dutch Bourtanger Moor in the Drenthe Province (the Netherlands), and in Denmark, they are particularly abundant.

The highest number of identified trackways (from all periods) belongs to Ireland, where more than 1300 *toghers* (from a few metres long, to >150 metres) have been recorded (Mcdermott, 2007: 24).

Different types of trackway, depending on the function, the period, and the material available, have been identified, with the most common ones being the brushwood, roundwood, hurdle, plank, and corduroy. Although the tendency is to order these types chronologically (e.g. brushwood earlier, and corduroy later), this division does not always work. For instance, the complexity and technological sophistication of the Late Bronze Age tracks in continental northern Europe tend to disappear in the Iron Age, when longer and more resistant (but more simplistically built) structures seem to be preferred. In Ireland, on the other hand, the *toghers* follow a more regular chronology; for instance, from the simpler Neolithic brushwood tracks of Corlea 8 and 9 to the more robust, longer, and more sophisticated corduroy ones of the Iron Age, such as Corlea 1 (Fig. 4.17) (Raftery, 1996*c*).

Apart from the Sweet Track (3807–6 BC) of the Somerset Levels, whose construction is unique, all the other above-mentioned types are found in most European bogs. The brushwood type, for example, although more used in Ireland (e.g. the Neolithic track of Corlea 8 and 9, and Derryoghil 2 and 4) and in the Somerset Levels (e.g. the Neolithic track of Bell and the Bronze Age ones of Viper and Tinney), is also found in continental Europe, and more precisely at Ipweger Moor, Germany (e.g. trackway XXX(Ip)) (Hayen, 1957, 1984), the Netherlands, and Denmark. The roundwood type (i.e. trackways made of longitudinally placed roundwoods) are those of Derryoghil 7, 8, and 29 (Bronze Age) in Ireland, trackway XXV(Ip) in Lower Saxon (Fansa and Schneider, 1990), and the Late Bronze Age one of XVIII(Bou) at the Dutch Bourtanger Moor (Casparie, 1984). Hurdle trackways are well represented in the Somerset Levels (e.g. the Neolithic trackway of Walton Heath and the Bronze Age Eclipse) (Coles and Coles, 1986), as opposed to in Denmark and the Netherlands where there are only a few examples (e.g. the Middle Neolithic trackway of Tibirke in Denmark and the Iron Age one of XIV(Bou) at Bourtanger Moor, the Netherlands) (Casparie, 1986*b*, 1987; Jørgensen, 1988). Plank paths consist of longitudinally laid planks usually secured by pegs. Examples of this type are the Bronze Age tracks of Corlona, Co. Leitrim and Curraghmore, Co. Offaly, the sixth-century AD Corlea 5 in Ireland (Raftery, 1996*e*), and the Bronze Age one of Meare Heath in the Somerset Levels (Coles and Coles, 1986; Coles and Orme, 1976). Plank paths in continental Europe are sometimes very similar to those in the British Isles (e.g. the Iron Age track of XV(Bou) at Bourtanger Moor, resembling that of Meare Heath, Somerset Levels). However, the single-plank walkway of XVI (Bou) found in the same area (Bourtanger Moor), is quite unique; in fact, no such constructions have been identified anywhere else in Europe (Casparie, 1984). Corduroy roads are made of transverses (split planks or roundwood

Fig. 4.17. The Corlea 1 trackway, Co. Longford, Ireland. (*Photograph*: Courtesy of the School of Archaeology, University College, Dublin)

stems) placed edge to edge on a substructure of longitudinal runners. In continental Europe they started being built quite early. The oldest one of this kind, which is incidentally the oldest wooden trackway in the world, is that of XXXI(Pr) (4780 cal BC), found at Campemore, Lower Saxony (Fig. 4.18) (Bauerochse, 2003).

Corduroy roads (*Bohlenwege* or *Pfahlwege* in German) are of crucial importance for the understanding the evolution of wheeled transport in prehistoric Europe. The difficulty of steering wheeled vehicles in the Neolithic required larger trackways (about 4 metres). From the Early Bronze Age onwards, the invention of the swingletree facilitated the steering of wheeled carts and consequently roads became narrower. One of the best examples of these Bronze Age trackways is track XVIII (Le) at Ockenhausen-Oltmannsfeld at Lengener Moor (Germany) (Fansa and Schneider, 1993). The roundwood planks of the trackways were first replaced by split planks in Lower Saxony around the middle of the second millennium cal BC. From then onwards a considerable effort was made to ensure a superstructure that was as level as possible. Standards of exceptional sophistication were not, however, achieved until the first half of the first millennium cal BC (mainly between the eighth and the sixth centuries), when in some cases the trackway surface was held together by thin straight laths of wood placed below and above the sleepers and fitted through slots in vertically projecting plank-like pegs. One of the best of the less than a dozen examples of this type of trackway (*Lochbohlenwege*) is that of trackway III(Pr) found at Grosses Moor (Lower Saxony) (Jacob-Friesen, 1963). Examples of corduroy trackways are also found in Denmark (e.g. Speghøje—Bronze Age), in Ireland (e.g. Derryoghil 1, tenth century BC; and Baunaghra, Co. Laois) (Raftery, 1996*e*). During the Iron Age (from about 500 cal BC onwards) the continental European trackways became less sophisticated, but at the same time extremely long (over 10 km). The longest ever built is the Iron Age (345 ±43 bc, or *c.*500 cal BC) trackway I (Bou) (the Valtherbrug), reaching 12 km (Casparie, 1986*a*, 1987). Further examples of this kind of trackway (which are remarkably similar of that of Corlea 1) are those of XXV(Pr) Schweger Moor, XLII Wittemoor, and VI(Pr) at Grosses Moor (Lower Saxony, Germany) (Fansa and Schneider, 1990; Hayen, 1971).

Not only do wooden trackways tell us about the various architectural techniques and carpentry skills of ancient wetland (and dryland) dwellers, but they also shed light on social interactions between different communities, wetland management (who had access to what in the bogs), and even climate change. The higher number of *toghers* in the Irish Mountdillon bogs during the second millennium cal BC may be, for instance, the result of an increase of wet conditions (Raftery, 1996*c*). The structure, length, and repairing of the *toghers* are also invaluable sources of information. In fact, a *togher* may have

Fig. 4.18. Trackway XXXI(Pr): the oldest wooden trackway in the world (4780 cal BC), Campemore, Lower Saxony, Germany. (*Photograph*: courtesy of Andreas Bauerochse, Lower Saxony State Service for Cultural Heritage, Germany)

been a temporary solution to reach specific places during wetter seasons, or it could have been a major construction, planned in advance, and used by various communities all year around. Although the majority of trackways were for utilitarian use, some of them may have had a sacred significance; they could have been, for instance, platforms for offerings (e.g. the XLII(Ip) trackway), or, with the presence of bog bodies, they may have had a more sinister function (see 'Bog Bodies', below). The numerous repairs of trackways, as well as some peculiarly marked planks obtained from the same trees but found 40 km apart (e.g. trackway IX (Le), Lengener Moor, and XII, Wittemoor), suggest a regional service responsible for the construction and maintenance of various trackways, covering a vast area. The size and length of these trackways should furthermore make us reflect upon the enormous community effort and organization of those social groups that built them. In some cases the quantity of material (wood) used was enormous. For instance, 600 planks, 350 piles, and 3,600 pegs would have been used to build the Sweet Track (Coles and Coles, 1989); 1500 planks and 6000 pegs for the XV (Bou) trackway in the Netherlands (Casparie, 1986*b*); and 450 hectares of forest would have been needed to provide the 65,000 planks for the 6.5-km long trackway of XII at Wittemoor (Fansa and Schneider, 1995), to mention but a few. Whether simply used for crossing, exploiting raw materials (e.g. iron ore resources), or exploring them for less profane purposes, road and trackway networks show an extremely high level of contact within and between the wetlands. The magnitude of these networks and the significant effort to develop and maintain them was certainly not restricted to wetland communities, but it was a joint cooperation of larger interregional and even cross-cultural groups.

In central and other parts of Europe (eastern Baltic Sea regions and western Russia) long wooden trackways were not built (or if they were, they did not survive). A few examples of trackways similar to those of northern Europe, although much shorter (a few tens of metres) are, however, found in the Lake Feder basin, southern Germany (see e.g. the Middle Bronze Age *Bohlenweg* of Bad-Buchau) (Billamboz, 1998; Schlichtherle, 2002). Short paths and walkways within, and leading to, lacustrine villages were nevertheless commonly constructed everywhere in Europe (e.g. crannog and island settlement walkways; or longer paths outside the lakeside villages, leading into the settlement, such as those of Chalain 19 (Lake Chalain, France) and Marin (Lake Neuchâtel, Switzerland) (Honegger, 2001; Pétrequin and Bailly, 2004).

Long wooden trackways are not found outside Europe, but, as within the European lacustrine villages, intra-settlement paths and walkways have been identified in China (Tianluoshan, *c*.2300 cal BC—path between rice fields), Japan (Juno, *c*.4000 cal BP), and New Zealand (see Ch. 2).

Water Transport: Dugouts, Rafts, and Plank Boats

Although archaeological assemblages show clear evidence of 'terrestrial' transport and communication networks within and between the wetlands (e.g. from simple pedestrian trackways to large wooden 'highways' for wheeled vehicles) (see e.g. Louwe Kooijmans, 2006; Pétrequin et al., 2006*c*; Schlichtherle, 2006*a*), the most common means of transporting goods and linking places was certainly by water. Whether dealing with marine, riparian, or lacustrine environments, people have always taken advantage of the various natural waterway networks since the Palaeolithic and possible even earlier. However, direct evidence of archaeological watercraft does not appear until the Early Holocene. In Europe (and possibly everywhere else in the world), the first watercraft (except of course natural unworked logs) consisted of dugout canoes (or logboats) hewn from large tree trunks. The oldest logboat is that of Pesse (8010–7510 cal BC—Jaap Beuker, pers. comm. 2010) (Fig. 4.19) in the Netherlands, followed by Noyen-sur-Seine (France) of slightly later date (7190–6540 cal BC) (McGrail, 2001: 173).

Although in some areas they appear at later dates (e.g. Ireland and England in the fourth millennium cal BC; in Sweden 500 cal BC; Norway AD 700; and Finland not until AD 1200), logboats are found almost everywhere, and they never go out of fashion. The size varies considerably (2–3 metres up to 15 metres), but does not follow specific chronological patterns. The style of construction also varies significantly; from simply shaped one-piece dugouts with no added parts, to composite ones (e.g. with transom boards and/or block-stem/bow timber). One of the best examples is the Iron Age (*c*.300 cal BC) logboat of Hasholme in the Humber Estuary (England) (Millett and McGrail, 1987). Another remarkable exemplar was the Brigg dugout (*c*.1000

Fig. 4.19. The Pesse dugout (about 3 metres long, 44 cm wide), the Netherlands. (*Photograph*: courtesy of the Drents Museum, Assen, the Netherlands)

cal BC) excavated near the River Ancholme in 1886, but unfortunately completely destroyed in an air raid in 1942 (McGrail, 2001). The technique of using transoms was not a later development (e.g. Bronze Age): some dugouts in Denmark (e.g. those of Horsekær, Halsskov, Zealand) were already constructed in this way in the Early Ertebølle Culture (*c*.6000–4800 cal BC) (Christensen, 1990, 1999). Dugouts are also found everywhere in the Circum-Alpine region, from the Neolithic to the Middle Ages. Even with the advent of plank boats and clinker later on, the use of dugouts (especially in swamps and lakes) continued until fairly recently. In addition to shedding light on the development of boat-building techniques, contextual studies on site location and site formation processes give us some clues as to how dugouts were maintained and repaired. For instance, stones and pebbles found in sunken dugouts have often been interpreted as ballast; however, the size of the stones and the location of the boats (especially when in shallow water close to the lake shore), suggest that they were sunk on purpose, by having large pieces of rock placed in them. This was done when the boat was not in use (possibly in winter) to prevent it from warping (Mcgrail, 2001: 174). One such example was found at Bernried on Lake Starnberg, Germany, where a Medieval logboat was filled with rocks up to 40 cm in diameter and sunk in a secluded part of the lake (Pflederer, 2009: 51). Another interesting find is the fireplace identified in some Danish dugouts. It is now known that it was used to provide heat and light for night spearing of eels (Andersen, 1994).

From the Bronze Age onwards, sewn-plank and plank boats began to be constructed. The best examples of excavated waterlogged sewn-plank boats are found in Britain: the Ferriby boats (2000–1700 cal BC), the Kilnsea (1800 BC), and the Brigg 'raft' (800 cal BC) in the Humber Estuary (McGrail, 1985; Van de Noort et al., 1999; Wright, 1990; Wright et al., 2001; Van de Noort, 2011), the Candicot fragments (1750–1100 cal BC), and the Goldcliffe fragments (*c*.1000 cal BC) in the Severn Estuary (McGrail, 2004), and the Dover boat in England (1550 cal BC) (P. Clark, 2004). Outside the United Kingdom, the first example of this type of boat is considered to be the Hjortspring (*c*.350 cal BC) in Denmark. However, some scholars have reservations as to whether it should be included in the sewn-plank category (McGrail, 2004). From AD onwards, new types of plank boat began to be developed; the flush-laid planking (fastened together with mortise and tenon joints), overlapping planking (fastened together by sewing), the nail-fastened clinker planking (similar to the Medieval Nordic tradition that would develop later), and the Romano-Celtic. Most of the boats of the latter tradition are canal and/or river barges, and they remained in use until the Medieval period. Their shape was particularly suitable for navigating deep as well as shallow rivers and lakes. Archaeological evidence has been found in Switzerland (Bevaix, Yverdon, and Avenches), along the main central European rivers, up to the North Sea, and as far as Wales (see for instance, Mainz and Xanten in Germany, Bruges in Belgium,

Blackfriars in England, and Berland's Farm in Wales) (Arnold, 1996, 2004; McGrail, 1988, 2001, 2004, 2006). From the eighth to the eleventh century AD, seas and rivers were dominated by fast and manoeuvrable clinker Viking ships (see also the waterway sail barriers and the Skuldelev ships) (Rieck, 2003), although, as pointed out earlier, dugouts and flat-bottomed Romano-Celtic boats continued to be used along the majority of European watercourses.

Outside Europe, waterlogged evidence of boats (excluding more recent maritime wrecks) is more limited. There are, of course, exceptions that prove the rule, such as Florida (see below). However, lack of evidence does not mean that inland navigation and waterway networks were less important than anywhere else. In China, for instance, up to the historical time, riparian water transport was the most widespread means of communication. The most common watercraft was certainly the logboat, which, contrary to previous opinion (Needham, 1971), continued to be used up to the twentieth century (Peng, 1988). The highest number of logboats is found in the Jiangsu province (21). Other provinces have also yielded some examples: for instance, Guangdong (7), Zhejang (5), Fujian (1), and Guangxi (1). Unfortunately, only a few have been dated, but the oldest amongst them are the two canoes of Zhejiang (*c.*4250 cal BC). Those of Guangdong are younger; one dating 221–206 BC, and the other 260 BC–AD 10 (Peng, 1988). Japan is also fairly rich in logboats; about 200 have been excavated in the past two decades. The main sites are those of Chiba, Tokyo, Osaka, and Torihama, which has yielded one of the oldest dugouts in Japan (*c.*3500 cal BC). Of similar date, or possibly even earlier, is the dugout of Hashinawate 1 (a ^{14}C date is still not available) (Takehiro, 2008). A place with a long tradition in navigation is New Zealand. A number of excavated *pa* (e.g. Kohika) have produced evidence of riverine as well as seagoing canoes with dugout hulls, separate lashed-on ends, planks, and thwarts (Irwin, 2006, 2004*b*). At Waitore Swamp, for instance, a decking plank, some paddles, and an outrigger float dating about AD 1500 have been identified (Cassels, 1979). The importance of the canoes and how the Maori used them was also recorded by Captain Cook when he was in the Hauraki Gulf and sent one of the Endeavour's boats inland, in 1769. More than one hundred dugouts were noted by Captain Dell around his ship when he arrived at Oruarangi (Furey, 1996).

As mentioned earlier, one of the most prolific places in terms of numbers of canoes found in waterlogged environments is Florida. There are currently more than 350 canoes on record there (Barbara Purdy, pers. comm. 2010), with the oldest specimen being that of De Leon Spring, dating *c.*5120 cal BC (Engelbrecht, 1994). A remarkable site that has yielded more than one hundred dugouts is Newmans Lake in the northern part of the state. The canoe chronology spans between 500 and 5000 years ago, although the main concentration lies between 3500 and 4500. The reason for such a high number of canoes grouped in such a small area is still unknown, however, a few theories

have been developed recently. It is possible that the site could have been a discard area (a sort of canoe cemetery), or it could have been a manufacturing place, or finally, the canoes could have been deposited by wind and drift (Ruhl and Purdy, 2005). Canoes were largely used all over North America, although a denser distribution (according to the archaeological evidence) is noticeable in the eastern part of the continent (from the Great Lakes to Mississippi and Florida).

In Mesoamerica and South America, pre-Columbian waterlogged dugouts have not been found. However, other types of watercraft, which have not survived, were certainly in use (e.g. possibly reed boats on Lake Titikaka).

Finally, an important element of navigation is the paddle. A large number have been found either along with canoe/dugout and plank boat finds, or in complete isolation. The style, size, and decoration vary considerably from place to place, but do not follow specific chronological patterns. However, the shape of them seems to be linked to different aquatic environments. For instance, shorter and heart shaped ones are preferred in shallow and vegetation-rich water basins such as fens and swamps, whereas those more round and wide were used in large lakes, bays and rivers free from aquatic vegetation (see e.g. the beautifully decorated Mesolithic paddles of Tybrind Vig, in Denmark—Andersen, 2011).

MATERIAL CULTURE

Are some of the objects found in wetland contexts uniquely wetland objects? It is very tempting to say 'yes', especially if examples such as the bog butter containers in Ireland and Scotland are taken into account (Earwood, 1997). And what about fish-hooks, harpoons, fishnets, and other fishing gear? They are indeed strictly linked to the wetlands, but not necessarily used only by wetland communities. Inland groups may develop a close contact with the wetlands and even base their subsistence and economy upon riparian and lacustrine environments, without necessarily living within them. The more one tries to distinguish between the two categories (wetland and dryland groups), the more one realizes how ephemeral the distinction is. The purpose of this section is certainly not that of identifying what is and what is not a wetland artefact, but rather to recognize those objects found in wetland contexts that can help us understand people's relationship with the wetlands. For instance, a beautifully carved part of a Maori *whare* purposely buried in an Aotearoan swamp is not only a serendipitously well-preserved object, but a piece of a jigsaw puzzle capable of shedding light on the Maori's fascination for the wetlands (Phillips et al., 2002). Similarly, a skilfully woven basket of the Northwest Coast of North America will not only please our eyes with its

aesthetic beauty, but has the potential of telling us more about the intricate patterns of cultural sensitivity and interregional relationships between groups (Bernick, 1998; Croes, 2001, 2003). Textiles are particularly important, for they are often found in wetland contexts, but the majority (including the raw material, e.g. flax) were produced in 'dry' environments. Paradoxically, bone and antler artefacts, as well as being imperishable objects, are perhaps the most crucial for the study of the wetland–dryland interface. In fact, while perishable objects are often only found in waterlogged conditions (or in exceptionally rare dry conditions), imperishable ones (often including bones and antlers) are also found in dryland sites, therefore allowing comparative studies (see Ch. 1, Fig. 1.9, and Ch. 5, under 'Preservation' and 'Conservation').

Wooden Artefacts

When studying wooden objects, in addition to the morphological structure and function of the artefacts themselves, other important analytical techniques have to be taken into account. For instance, the identification of the wood species is crucial, as it may retain hidden symbolic values linked to the cultural choice (e.g. the importance of the chestnut in the Early Jomon Culture; or the cedar as a link between sacred and profane life on the Northwest Coast of North America) (Kobayashi, 2004; Stewart, 1984). The anatomical characteristics of the objects in relation to the parent tree from which they were obtained, as well as the wood-dressing techniques and tools used, are also crucial for establishing the provenance of the objects and their chronology (O'Sullivan, 1996; Sands, 1997) (see also Ch. 6, under 'Dendrochronology').

It is virtually impossible to list the entire variety of portable wooden artefacts found in wetland and/or wet contexts. However, it may be useful to allocate them to subdivisions according to their functions and construction techniques. In general, the most common wooden objects found in the wetlands are containers, ranging from carved and hollowed single-piece containers to more technologically sophisticated sewn bark, bent wood basketry (see below), and coopered ones. The second most common items are tools, which, depending on the period, can range from simple handles or digging sticks to more complex agricultural implements such as yokes, ards, and ploughs. Hunting and fishing gear include bows, arrows (with flint arrowheads, or the so-called blunt-ended bird bolts, also made of bone and antler—see below), spearheads, and clubs. In this section covering portable wooden artefacts, objects such as dugouts and boats, travois, wheeled vehicles, coffins, anthropomorphic and zoomorphic sculptures, parts of buildings, and other wooden structures in general are not included, since they are discussed elsewhere.

As eloquently shown by the *c*.400,000-year-old wooden spearhead of Schöningen, Germany (Thieme, 1997, 1999), the fact that waterlogged archaeological evidence starts mainly from the Mesolithic onwards does not imply that wooden artefacts were not in use earlier. However, it is indeed from the Mesolithic that the first evidence of wooden containers dates. Some of the earliest are the birch-bark containers of Nizhneye Veretye (about 10,000–9,000 years ago), Russia (Oshibkina, 1989), Friesack (8950 ±110 BP) Germany (Gramsch, 1989, 1992, 2000), and Vis 1 (*c*.8000–7000 BP), Russia (Burov, 1998). Birch-bark containers remained the most widespread type of organic material items in north-eastern Europe and Russia until the end of the Late Iron Age, and in some areas even in historical times. Evidence of waterlogged containers in other parts of the world contemporaneous to the Mesolithic in Europe is very scarce; and, due to preservation issues, evidence remains limited to more 'recent' times.

From the Neolithic onwards there was a noticeable increase in wooden containers of all sorts, all over Europe. Birch-bark was still the main material used in some parts of the continent (see for example, the finely sewn bottom of the Bruszczewo container in Poland) (Czebreszuk, 2005), whereas in other parts, such as in the Circum-Alpine region for instance, carved and hollowed single-piece containers were more common. This latter type of container is found throughout the Neolithic, and until the beginning of historical times. Some of the best Neolithic examples are the numerous spoons, ladles, bowls, and dishes of Egolzwil (Switzerland) (E. Vogt, 1951; Wyss, 1973, 1976); the bowls of Niederwil, Lake Egel (Switzerland) (see Fig. 4.20) (Waterbolk and van Zeist, 1991); the ladles of Charavines (Bocquet, 1990; Bocquet and Huot, 1994; Bocquet et al., 1987); the oak tub and Maplewood cups from Reute-Schorrenried, Lake Feder (Schlichtherle and Wahlster, 1986); and the wooden dishes and trough found next to the Sweet Track, Somerset Levels (Coles and Coles, 1986).

Although still produced in the Bronze Age (see Fiavé, former Lake Carera) (Perini, 1987), carved and hollowed single-piece wooden containers are less popular in the Iron Age, when coopered, joined, and even turned ones started to appear. One of the best examples of a coopered container is the finely carved Bronze Age birch-bark jewellery box (containing shell, glass, and amber beads) from ZH-Grosser Hafner (1050–850 BC). Coopered wooden tubs have also been found at the lake village of Glastonbury (Coles and Minnitt, 1995; Tuohy, 2004), whereas the most succinct examples of turned wooden containers are found at the Iron Age–Roman period settlement of Feddersen Wierde, northern Germany (P. Schmid, 2002). From the Early Medieval period onwards, waterlogged evidence of wooden containers in Europe diminishes. This is once again a matter of preservation; broken small containers as well as large barrels are burnt as fuel rather than discarded. On the other hand, remarkable evidence of wooden containers of the past millennium is found in New Zealand, where beautifully carved wooden bowls have been

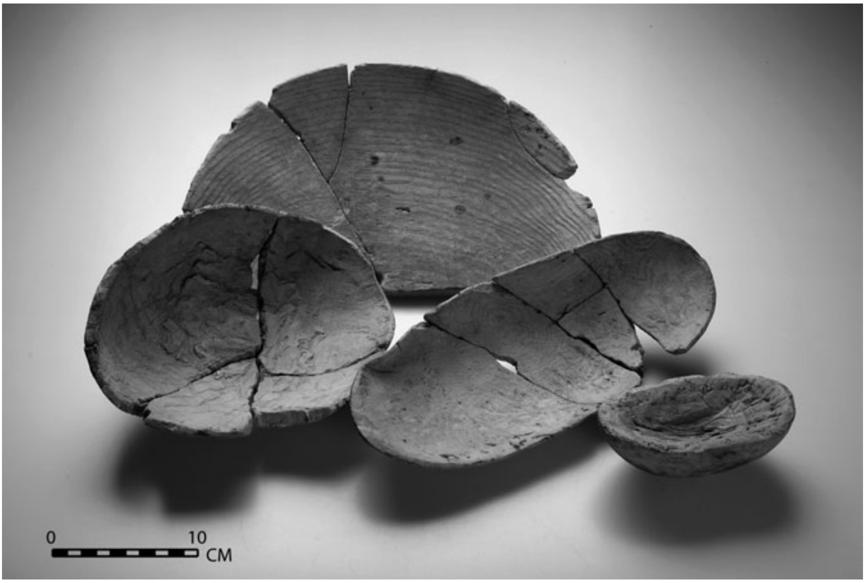


Fig. 4.20. Hollowed single-piece bowls from the Neolithic settlement of Niederwil, Lake Egel, Switzerland. (*Photograph*: courtesy of the Amt für Archäologie Thurgau, <www.archaeologie.tg.ch>)

located at Gisborne, Taranaki, and Te Awamutu (Johns, 1998), and canoe bailers at Kohika (Wallace and Irwin, 2004).

Agricultural wooden tools and weaponry (bows, arrows, clubs, composite stone axes, and flint knives) were probably the most numerous artefacts up to the beginning of the use of metal, and in some regions of northern Europe even much later. In some areas of New Zealand, Australia, central and western Africa, the Northwest Coast of North America, and the entire Amazon Basin in South America, wood continued to be the most common material used by wetland communities until very recently. Well-preserved wooden implements have not only the potential of shedding light on the diachronic advance of technology through time, but they can also help us understand cultural change and adaptation processes in relation to the surrounding environment. For instance, the large quantity of blunt-ended bird bolts found in north-eastern Europe as well as in north-western Russia (e.g. Vis 1 in Russia, and the Kryvina peatbog in northern Belarus) could only be understood in association with the large quantity of migratory waterfowl fauna remains (Burov, 1998, 2001, 2009; Charniauski, 1997, 2007; Zhilin, 2007; Zhilin and Matiskainen, 2003). Another plausible example is the development of ards and ploughs. Technical characteristics of single ard-heads or composite ploughs (beam, foreshare, mainshare, tang of mainshare, and stilt) would only be isolated pieces of a jigsaw puzzle without their association with yokes and, most

importantly, a full understanding of animal traction development. It is therefore only by joining the pieces together, for instance plough-mark studies with ard and plough physical remains, along with a comprehensive understanding of animal traction and its consequences on the physical characteristics of the animals (e.g. bone stress and osteopathologies), that the full picture of cereal cultivation amongst farming communities will start to emerge (Lignereux et al., 2006; Louwe Kooijmans, 2006; Marzatico, 2006; Pétrequin et al., 2006*b*; Pétrequin et al., 2006*a*).

There are also composite objects (made of organic and inorganic material), such as wooden handles of stone and metal axes, or flint inserts for knives and sickles, whose organic component is crucial for the understanding and interpretation of the artefacts themselves. In the absence of the organic part, the artefacts are unrecognizable, as is, for instance, the case of knives and sickles made of flint inserts; once the handle is gone it would be impossible to know that the remaining scattered flint flakes were once part of a sickle (see the sickle from Fiavé, Fig. 4.21).

Another example is the Neolithic net sinker of Twann (Lake Biel), made of small pebbles wrapped and tied with bark (Stöckli, 1990*b*). Had the bark and cordage disappeared, it would have been impossible to identify the object as a net sinker.

Unusual Artefacts

In addition to the quite common (in wetland contexts) array of wooden agricultural artefacts and weaponry, waterlogged environments also yield particularly rare and finely crafted items made of organic material. These can be divided into musical instruments (see e.g. the Roman syrinx (panflute) of Eschenz, Switzerland, Fig. 4.22) artistic wooden carving (see 'Anthropomorphic and Zoomorphic Wooden Figures' below), and utilitarian objects. There are quite a few examples of this latter category within the Circum-Alpine region lake-dwelling tradition. One of the best-known objects is the Neolithic axe of Cham-Eslen (Lake Zug, Switzerland), whose long, straight handle was wrapped with finely cut and decorated birch-bark (Fig. 4.23) (Gross-Klee et al., 2002; Huber et al., 2009).

Other examples of prehistoric arts and crafts using birch-bark are the Neolithic clay pots of Estavayer, Saint-Aubin-Tivoli (Lake Neuchâtel) (Egloff, 1990), Hitzkirch (Lake Hallwil) (Bleuer et al., 2004), and Egolzwil (Wauwiler Moos) (Wyss, 1976), where birch-bark was 'glued' on the still-wet clay as decorative patterns. It is astounding the myriad of ways that birch-bark was used in prehistory. In north-eastern Europe and north-western Russia it was even used to repair broken pottery. In the settlements of the Kryvina peatbog for example, the broken fragments of a vessels were perforated and rejoined with plant fibre and underlying birch-bark (Charniauski, 2006). Interestingly, this technique of fixing pottery was also used by the Tripolye Culture people in Ukraine during the Chalcolithic (Kruts et al., 2008).

Fig. 4.21. The Bronze Age wooden sickle with flint inserts from Fiavé, northern Italy. (After Marzatico, 2004: 87)

Fig. 4.22. The 11-cm long Roman (first century AD) Syrinx of Eschenz, Switzerland. (*Photograph*: courtesy of the Amt für Archäologie Thurgau, <www.archaeologie.tg.ch>)

A final category of artefact worth mentioning is the hair combs. This type of artefact is found in a large number of wetland sites around the world; from northern Europe to the Circum-Alpine region, Japan, New Zealand, and North America. Although the majority of early combs are made of wood, some were also carved from bone and antler (e.g. the Neolithic antler comb of ZH-Mozartstrasse, the Bronze Age ones of the *terramare* in northern Italy,

Fig. 4.23. The Neolithic axe of Cham-Eslen (Lake Zug, Switzerland), showing the finely cut birch-bark used to wrap the wooden handle. (Courtesy of the Kantonsarchäologie Zug, Sabina Nüssli)

and a few more in Bronze Age and Iron Age Denmark). Some of the best exemplars of wooden Neolithic combs are those of Arbon-Bleiche 3 and Sipplingen (both on Lake Constance), and that of Sutz-Lattrigen (Lake Biel) (Leuzinger, 2002; Schlichtherle, 1997*b*). Outside Europe, wooden combs have been found at Hoko River (*c*.3000–1750 cal BP) on the Northwest Coast of the United States; at Torihama in Japan, where a beautifully carved 6500-year-old *Camellia japonica* comb was even painted with lacquer; and finally at Kauri Point in New Zealand, where a remarkable collection (187) of deliberately broken combs were ritually deposited (Shawcross, 1976).

Weirs and Fish-Traps

Fishing activity includes a myriad of techniques and fishing gear, spanning from simple line fishing to harpooning, net fishing, fish-traps, and weirs. Although the use and efficiency of these various techniques changed according to place and time, the latter two techniques were probably the most efficient before the advent of fish farming. Weirs were most commonly used by coastal communities within estuary environments, but archaeological evidence of them has also been found inland, along rivers and even by lakes. Fish weirs are fence-like structures set in estuary tidal channels in order to guide fish into specific traps where they will be collected later. In most cases, archaeological evidence of weirs consists of upright wooden stakes placed in a V-shape, and extending fully or partly across the tidal channel or river. Fish can simply get stranded in the V-shaped structure with the outgoing tide (estuary case), or be channelled into a portable basket-like trap (or even into spiral-shaped weirs—see Shidanai, Japan) along the current of the river or watercourse. Some weirs include removable elements, such as lattice-work panels, or basketry containers; consequently a weir can also be called a fish-trap.

In northern Europe and Scandinavia, weirs and other permanent fishing structures are known since the Mesolithic, with the oldest being at Kalø Vig I (7550 ±40 BP) in Denmark (Connaway, 2007). One of the best examples of Mesolithic weirs is found at Halsskov Overdrev, a former fiord (now a peatbog) on the Great Belt (Zealand, Denmark). Here, various wattle panels forming a number of weirs were constructed between the Middle Ertebølle and the Funnel Beaker period continuing in some cases until the Pitted Ware Culture (see Ch. 2 for chronologies) (Pedersen, 1999). Similar fish weirs were identified at Šventoji 9 (Lithuania) and at Zamostje in the Upper Volga region, whereas conical basket-like nets, or nets with wooden frames, were found at Sarnate (Latvia), Šventoji 1A and 2B (Lithuania), Sakhtysh (Russia) (Lozovski, 1999; Rimantienė 1992*a*, *b*), and Steckborn-Schanz, Switzerland (see Fig. 4.24). Beautifully made Early Neolithic dogwood basket fish-traps (presumably for eel fishing) have also been found at Bergschenhoek in the Netherlands (Louwe Kooijmans, 1987). Fish weirs are also found in the British Isles and in Ireland.

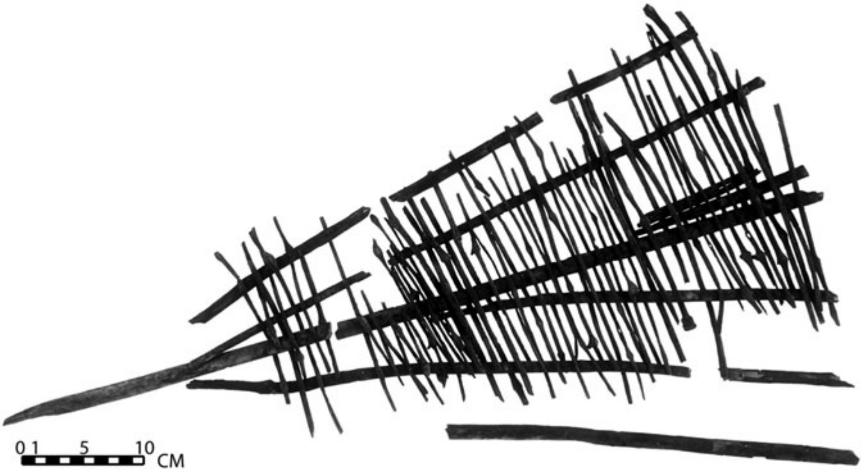


Fig. 4.24. Neolithic (Pfyn Culture) fish-trap of Steckborn-Schanz, Lake Constance (Untersee), Switzerland. (*Photograph*: courtesy of the Amt für Archäologie Thurgau, <www.archaeologie.tg.ch>)

Two of the best-known locations are the Severn Estuary (England and Wales), and the Shannon Estuary (Ireland). In both cases, weirs were built from the Neolithic onwards, although the majority began to be constructed in Medieval times (see e.g. the fish-traps at Carrigdirty Rock and those of Bunratty in the Shannon Estuary, Ireland—see Fig. 4.25) (O'Sullivan and Daly, 1999).

Early Medieval weirs have also been found in the Blackwater Estuary and the Stour Estuary in Essex, England (Gilman, 1998). Weirs were also constructed in inland rivers and even in lakes (usually near river outlets). In prehistoric times the best example of a lacustrine fishing complex is the Iron Age (*c.*720–620 BC) weirs (with possible fishing huts) of Oggelshausen-Bruckgraben, Lake Feder, Germany (Köninger, 1999, 2002). Interestingly enough, this is the only evidence of Iron Age occupation on Lake Feder; no settlements of this period have ever been found. Examples of Medieval fish weirs of the riparian/lacustrine type have been found on the River Limmat (near Zurich Bay) and in Rapperswil, on Lake Zurich (Eberschweiler, 2004: 168). Weirs continued to be built throughout the Middle Ages and up to the nineteenth century. One weir at Kappeln, Schleswig-Holstein, Germany, is, surprisingly, still in use today (Roth Heege, 2007: 191).

Weirs and fish-traps are ubiquitous features of prehistoric and historic fishing activity, and waterlogged evidence of such structures is found in various places all over the world. However, an area with one of the highest concentrations (more than 1000) of estuary, riparian, and coastal weirs is the Northwest Coast of North America; from the various estuaries of the Oregon Coast (United States), to

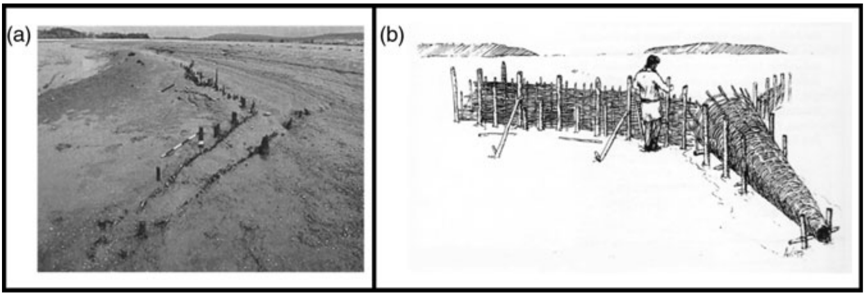


Fig. 4.25. *In situ* remains (a) and schematic reconstruction (b) of the Bunratty 6 Medieval fish-trap in the Shannon Estuary, Ireland. (*Photograph and drawing*: courtesy of Aidan O'Sullivan)

British Columbia (Canada), as far as Alaska (Mobley and Mccallum, 2001; Moss and Cannon, 2011; Moss and Erlandson, 1998). In Oregon, for instance, from a study including some of the main estuaries and bays (Coquille, Coos, Siuslaw, Yaquina, Netarts, and Nehalem), not only has Byram (1998) been able to identify a number of weirs of the past two thousand years, but he has also classified them into different types: (*a*) tideflat weirs, (*b*) cross-channel tidal weirs in tidal sloughs, and (*c*) cross-channel non-tidal weirs (including the channel margin weirs) (Byram, 1998: 206). The study concludes that different species of fish were harvested using different lattice weir panels, and the size of the lattice gauge depended upon the targeted catch. Furthermore, in some cases (e.g. at Coquille), the location of the weirs in relation to their chronology has helped in reconstructing the dynamics of the constantly changing estuary morphology (Ivy and Byram, 2001). Similar studies of three sites within the Fraser River estuary area (Canada) have helped identify changes in fishing techniques between 4600 and 200 years ago. For example, the simple traps used at Glenrose Cannery 4600 years ago were replaced by gill nets at Musqueam Northeast, 1600 years later. Around 2000 years ago, the latter went out of fashion and trawl nets began to be used (Stevenson, 1998).

Fish-traps and weirs have also been located in other parts of the North American continent. Two of the best examples are the basket-like fish-trap of Montana Creek in Alaska (also important for geomorphological studies and palaeoenvironmental reconstructions—see Ch. 6), and the mysterious agglomeration of stakes (about 65,000) interpreted as a series of fish weirs spanning the period from 5000 to 3700 years ago, found at Boylston Street in Boston, Massachusetts (Décima and Dincauze, 1998).

In tropical places, due to poor preservation, prehistoric weirs and fish-traps are more difficult to locate. However, in some areas of central and western Africa, Asia, Oceania, and Central and South America, with a special emphasis on the Amazon Basin, the use of weirs and fish-traps has a long tradition, and in some cases local indigenous populations still construct them today.

Basketry and Cordage

The contribution to archaeology made by basketry and cordage artefacts found in waterlogged conditions is remarkable. Spanning from the Early Holocene to just about the present, basketry and cordage items not only offer a glimpse into our ancestors' skills in manipulating plant fibres, but they also tell us more about the delicate relationship between people and the environment from which the raw material was obtained. Depending upon the level of preservation and the importance that basketry and cordage traditions had within a specific cultural group, they can even go a step further and shed light on social aspects that reflect cultural continuity (or the lack of it) within a specific cultural group, or its diachronic development as well as interaction with other interregional communities. If superficially considered, the ubiquitous distribution of wetland basketry and cordage artefacts and their apparent similarities of weaving techniques may be misinterpreted. However, as with pottery, the creation and development of a specific way of weaving reflects cultural sensitivity between contemporaneous groups, or within the diachronic perpetuation of a single family group, household, or community. The remarkable preservation of Friesack material culture has, for instance, allowed the identification of technological differences between the first (*c.*9000 cal BC) and the third (*c.*7850 cal BC) phase of occupation. Within the first three hundred years, people used knotless netting and plaited ropes. These two techniques were replaced by the 2-ply strings and knotted nets in the second occupation, but, interestingly enough, whoever settled there in the last phase used the same techniques as the first settlers some two to three hundred years earlier (Coles and Coles, 1996; Gramsch, 1989, 1991, 1992) (see also Fig. 4.26).

A similar case is found at Danger Cave in Utah, where excellent stratigraphic control made it possible to identify a change in basketry techniques (with raw material collected from the wetlands) over a time span of about 6000 years (12,000–6000 years ago); from an initial use of only the twining technique (12,000 years ago), to a 15 per cent twining and 85 per cent coiling around 6000 years ago (Jennings, 1989).

The most diverse collection of basketry work, including woven mats, raincoats, hats, and shoes is found within the lake-dwelling tradition of the Circum-Alpine region from the Neolithic to the Late Bronze Age. For instance, evidence of hats made of bast has been discovered on both slopes (north and south) of the Alps, as is shown by the Neolithic finds of Hornstaad-Hörnle 1A, Wangen-Hinterhorn, Sipplingen (Lake Constance, Germany), Seekirch-Achwiesen (Lake Feder) (Feldtkeller, 2004), and the Bronze Age rigid conical hat from Fiavé (Perini, 1987). Similarly, evidence of bast-woven shoes was found at the Neolithic sites of Allensbach (Lake Constance) and Saint-Blaise/Bains (Lake Neuchâtel) (Schlichtherle, 1997*b*). An insole moss

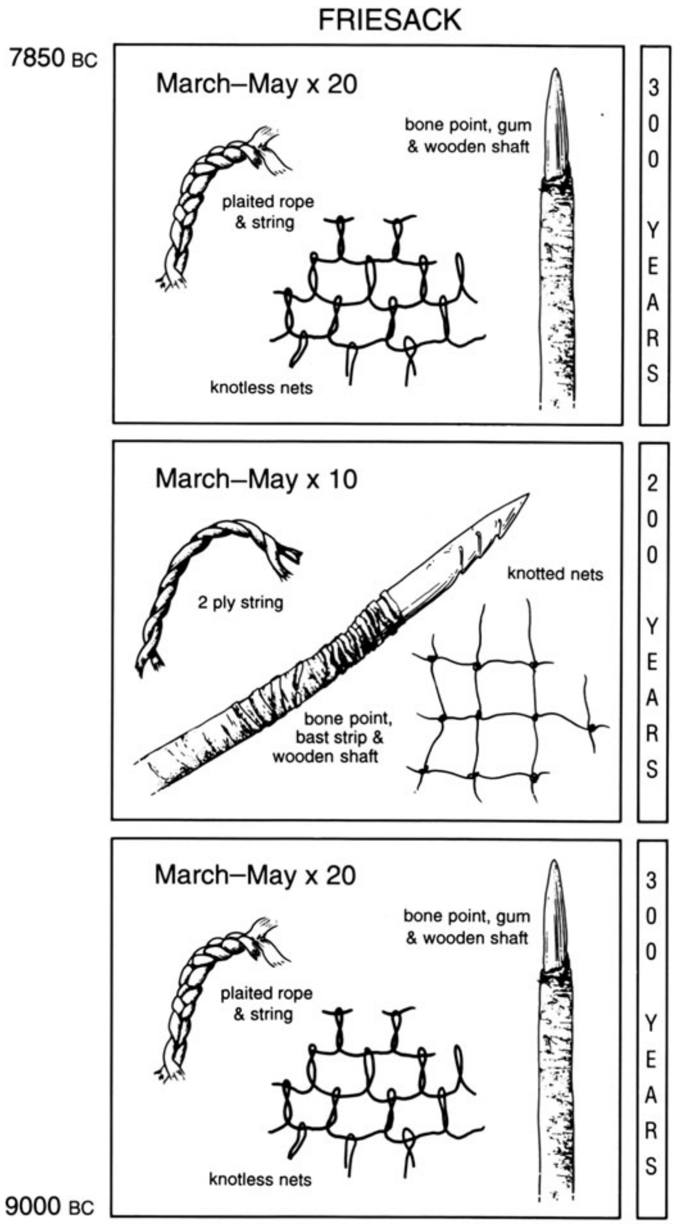


Fig. 4.26. Chronological change in material culture at the Mesolithic site of Friesack, Germany. (© Somerset Levels Project—John and Bryony Coles)

pad with therapeutic properties was also found at Zug-Schützenmatt (Lake Zug) (Hochuli, 2002; Leuzinger, 2004; Schibler, 2001*b*). Although typological analyses of these hats have been carried out (Feldtkeller, 2004: 59) and analogies between the contemporaneous Zug-Schützenmatt and Ötzi's shoes have been attempted (Reichert, 2000: 69), cultural sensitivity of the objects has not as yet been proved. Wetland sites on the Northwest Coast of North America have, on the other hand, exceeded all expectation in terms of identifying subtle cultural and social differences. Here, comparative studies as well as cladistic analyses on basketry remains of the past 4000 years have allowed scholars to identify cultural differences and similarities amongst the different local communities through space and time (Bernick, 1998; Croes, 1995, 1997; Croes et al., 2007). The results have been remarkable and in some cases even unexpected, such as the marked cultural dislocation (as opposed to the expected cultural continuity) in the Coast Salish area (Bernick, 1998: 153). With the possibility of ethnographic comparisons, as well as first-hand involvement with local First Nations communities, the potential of basketry and cordage studies is enormous. A succinct example is Croes' attempt to identify a person's life cycle from birth to death. In his study, Croes (2001) eloquently shows how basketry items are specifically constructed to contain humans at birth (e.g. cradles), how other objects (e.g. hats and harpoon sheaths) accompany people through their developing life and social status, and, finally, how woven mats are used as mortuary shrouds at the end of people's lives.

Plait work and netting are also found in New Zealand, where, however, cultural sensitivity is more difficult to detect, as opposed to wood carving that does indeed allow cultural and chronological distinction between the various techniques (Johns, 2001; Mead, 1995; Simmons, 1994).

Textiles

Although wooden structures of looms have not been found in waterlogged environments, the presence of a large number of spindle whorls (see Fig. 4.27), loom weights, bundles of fibres, and above all, entire and/or fragmented clothes proves that weaving activity was certainly germane within past societies (Altorfer, 2010; Altorfer et al., 2001).

Some of the best evidence of clothes comes from the peatbogs of northern Europe (e.g. the Yde girl's woollen cloak in the Netherlands, and the woollen skirt from Damendorf, Germany), or from the permafrost funerary sites of Siberia. Although more limited than in the peatbogs, early traces of textiles are also found in other parts of Europe, from Scandinavia to the Alps. During the Neolithic, the main concentration of finds is once again in the Circum-Alpine region (see e.g. the large bundles of bast thread of ZH-Kleine Hafner, Lake Zurich and Twann, Lake Biel; or the finely woven fragment of linen garments of ZH-KanSan, Lake Zurich; Molina di Ledro, Lake Ledro, northern

Fig. 4.27. Spindle whorl and shaft covered in linen thread, from the Neolithic site of Arbon-Bleiche 3, Lake Constance, Switzerland. (*Photograph*: courtesy of the Amt für Archäologie Thurgau, <www.archaeologie.tg.ch>)

Italy; Niederwil, Lake Egel, Switzerland (see Fig. 4.28); or the rolled-up panel of linen cloth from Twann, to mention but a few) (Hafner and Suter, 2000, 2004; Suter and Schlichtherle, 2009). Remarkable evidence of waterlogged textiles also comes from North America, and more specifically from Fort Center (Lake Okeechobee, Florida), where large textile sheets were used to wrap corpses before placing them on the elevated platform above the water, or from Windover (also used for mortuary practices) (see also 'Mortuary Practices', below). The sophistication of the Sabal palm/Saw palmetto fabrics

Fig. 4.28. Fragments of linen textile from the Neolithic (Ffyn Culture) lake-dwelling of Gachnang-Niederwil, Lake Egel, Switzerland. (*Photograph*: courtesy of the Amt für Archäologie Thurgau <www.archaeologie.tg.ch>)

was astonishing; there were more than five variants of twining/weaving, and in some cases up to ten strands per centimetre have been identified (Doran, 2001*b*, 2002).

Bone and Antler Artefacts

The fact that bone and antler artefacts are found in both wetland and dryland archaeological assemblages facilitates comparative analyses and a better understanding of the interface between the two areas, which may not be possible with items only preserved in waterlogged conditions. Although bone and antler objects are found in almost all wetland archaeological assemblages all over the world, because of the favourable preservation properties of the soils in which the artefacts lay (low oxygen content in soil, fairly high pH, and calcareous water—see Fig. 5.17), the lakeside settlements of the Circum-Alpine region have yielded a remarkably high number of objects. This

significant amount of evidence (both from food discards or tools) have contributed to shed light on hunting activity, food procurement, economy, and tool, weaponry, and arts and crafts technology. For example, although both domestic and wild animal bones and antlers were used, a preference for wild animals is noticed. Antlers of red deer were highly exploited, and the majority of them were shed antlers (Schibler, 2001*b*). Only during difficult periods (crop failure, unfavourable climatic conditions, and demographic pressure) were the deer over-hunted and therefore also antlers that had not been shed were used (see Box 3.1). One of the most common types of antler artefact found in the Circum-Alpine region lake-dwellings is the stone axe sleeve/socket (see Fig. 3.4), which is a hollow piece of antler placed between the handle and the blade to absorb the blow, thereby reducing the danger of breakage.

As far as bone objects are concerned, the most common one is probably the double-pointed awl used for arrows (one was even found stuck in a doe's pelvis at Sutz-Lattrigen- Hauptstation (Lake Biel) (Hafner and Suter, 2000), spears, harpoons, and fish-hooks (Torke, 1993). Teeth (especially canine) and small boar tusks were also used as amulets or necklaces, as the nice collection of perforated teeth from Sutz-Lattrigen Hauptstation and Rütte shows. In some cases (e.g. at Twann, Lake Biel), even dog metapodials were used as pendants (Hafner and Suter, 2004). Contrary to what was previously taken for granted, perforated long boar tusks were probably not part of a necklace pendant, but simple attached to a person's belt by a string and used as a pointed tool (Schibler, pers. comm. 2010).

Archaeological experiments with bone and antler materials have also shed light on cutting, grinding, polishing, and perforating techniques used to make the artefacts. It is now commonly agreed that antlers were worked while still fresh; there is also the possibility that specific substances obtained from plants and mixed with water could have been used to keep the material wet until the work was completed (see also Ch. 7).

As noted above, bone and antler objects are found in various wetland sites worldwide, but the uniqueness of bone carving found at the Kohika site in New Zealand is not matched in any other wetland contexts (it has to be pointed out, though, that bone carving is not just a characteristic of the Maori communities living in the wetlands—the same kinds of artefact are also found in dryland occupations). Apart from a few awls and chisels, the majority of carved bone artefacts at Kohika consist of pendants and fish-hooks made of human and dog bones (Fig. 4.29) (Irwin, 2004*a*).

Finally, hundreds of composite bone artefacts (bone-wood and bone-shell) have also been found at Ozette, Northwest Coast of the United States, with the most striking object being the wooden whale fin inlaid with more than 700 sea otter teeth (Daugherty and Friedman, 1983).

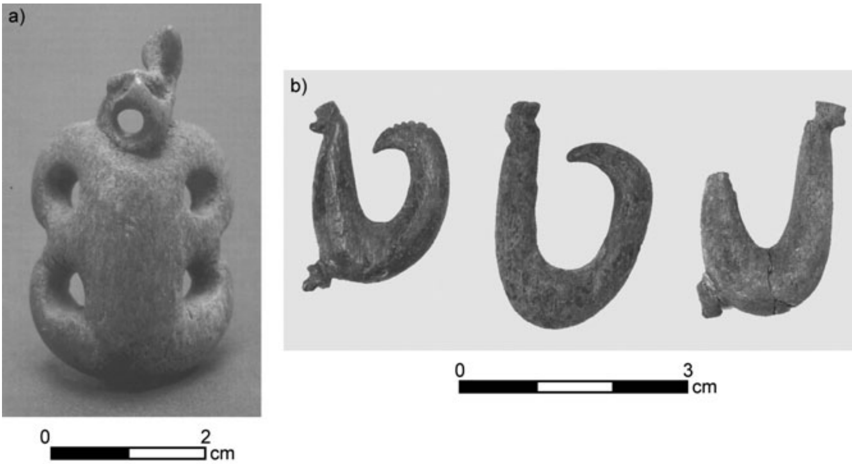


Fig. 4.29. Maori tiki pendant (a) and fish-hooks (b) (both made of human bone) from the Kohika *pa*, New Zealand. (Courtesy of Geoffrey Irwin, University of Auckland, New Zealand)

SACRED PRACTICES AND BELIEFS IN THE WETLANDS

Because of their dual ambiguity (water bringing life, but also taking life away), wetland environments have always been considered as physical as well as spiritual boundaries. As a result, they are not only sources of life for subsistence, but also liminal places, functioning as a sort of interface between the physical and the spiritual worlds. In this section, the focus is placed upon the latter, exploring the different ways people interact with the wetlands in order to express their beliefs. It has already been seen how the wetlands (mainly peatbogs) were explored and crossed by means of trackways; now the discussion will focus on how some of these trackways were used for more sacred purposes, and/or how other, additional structures (e.g. post alignments, platforms, cults houses, timber circles, and other wooden structures) were built and functioned in people's everyday lives. The delicate balance between 'give' and 'take' is shown by the numerous hoards, offerings, and ritual depositions that took place within the wetlands. A myriad of objects ranging from stone axes to anthropomorphic and zoomorphic wooden figures (sadly, even human sacrifices) were used to communicate and/or negotiate with ancestral spirits, gods, and other sacred entities. The ultimate function of specific wetlands (bogs and shallow ponds) was that of facilitating the passage from the earthly existence to the afterlife. Although not commonly used, funerary practices within watery environments (pond and bog cemeteries and dugout internments and cremations—see below) have been noted in various parts of the world, from the Early Holocene onwards.

Ritual Architectural Structures

As pointed out in previous sections, trackways in bogs may have had a double function. They were used as 'highway networks' within and between bogs, as well as offering and sacrifice platforms from which to deposit various objects for sacred purposes. In addition to trackways, specific buildings and particular wooden structures were constructed and used as qualitatively different places within a more profane landscape, settlement, or even single house (T. Brown, 2003). At a settlement or village level, specific buildings had particular functions, which extended beyond purely practical purposes. Within the Tripolye Culture for instance, sacred and profane were fused together in each single house; oven, sleeping areas, and working spaces were situated in the same room as the altar where the interaction with the spiritual world took place. Such an integration between sacred and profane in limited spaces is hardly seen within wetland communities of prehistoric Europe. However, it has recently been noticed that within the lake-dwelling tradition of the Circum-Alpine region, similar building may also have existed. Because of their substantially different architectural characteristics, it is argued that they had particular functions. One of the best examples is found at Marin-Les-Piécelettes (Lake Neuchâtel), where a construction, built on top of an artificial mound, was located within the village, exactly at the end of a more than 100-metre-long causeway. A second example is that of Ludwigshafen-Seehalde, where the walls of a house were plastered with clay protuberances shaped as female breasts (possibly linked to the female fertility cult), and painted with particular motifs, commonly found in the Danube region and in the western Mediterranean (Schlichtherle, 2006*b*). Special-purpose houses (*Whakairo*) were also built within the Maori *pa* in ancient Aotearoa (R. T. Wallace et al., 2004).

Entire special residential agglomerates were also constructed in difficult-to-reach, secluded wetland areas. One of the best examples is the platform of Alvastra (Sweden), consisting of seventeen clustered rooms for special gatherings. The site was occupied about 5100 years ago and abandoned only after eighteen years. Ceremonial objects such as pottery and miniature axes made of amber, flint, and bone are part of the Alvastra archaeological assemblage. A few burials (carried out about two decades after the site was abandoned) were also identified (Göransson, 1995; L. Larsson, 2001).

Non-residential units for gatherings, such as timber circles, wooden temples or post alignments, and platforms are also known in other parts of the world. On the British Isles, the best examples are Seahenge (the timber circle of Holme-next-the-Sea, England), dated at 2200–2000 BC (see Fig. 4.30) (Watson, 2005), and the post alignment of Flag Fen near Peterborough (Pryor, 2005).

Similar circular wooden enclosures also appear in Japan, but the posts are enormous (up to 1 metre in diameter). One of the best known of these circles is

Fig. 4.30. Seahenge, Holme-next-the-Sea, England (© English Heritage)

that of Mawaki (Late Jomon period, *c.*2645 ±25 BP) (Yamada, 1986). Scholars' opinions on the function of these large constructions are divergent; some believe that they were ritual centres and others that they were simply watch-towers (Matsui, 1999: 154). Of rather different shape, but still believed to be a ceremonial centre, is the square structure with horizontal wooden planks on which vertical horned posts were erected of Bargeroosterveld at Bourtanger Moor (the Netherlands) (Coles, 1984). Interestingly enough, despite the few offering objects found near the Flag Fen post alignment, and ceremonial artefacts scattered within the Alvastra gathering centre, no major depositions or hoards have been found in or near those two sites.

Hoards, Offerings, and Depositions

Although as pointed out by R. Bradley (1990), offerings and ritual depositions occurred in both wetland and dryland contexts, archaeological evidence in the wetlands seems to prevail. Unlike wood and other organic materials whose preservation is facilitated by waterlogged conditions, votive artefacts for ritual depositions are often made of inorganic materials, therefore not necessarily needing anaerobic conditions to be preserved. As a result, the higher number of ritual depositions in the wetlands seems to be linked to a preference for watery environments to perform this kind of activity.

Votive depositions in the wetlands take two different forms: single- and multiple-object depositions. In both cases identification problems may arise. In the absence of a specific context, single-object depositions can be misinterpreted as chance losses. Similarly, multiple-find ones may be multiple diachronic depositions, which may be difficult to distinguish. The objects deposited vary considerably from place to place, although some are characteristic of specific periods (e.g. stone and flint axes and pottery in the Neolithic, metal objects in the Bronze Age). The objects deposited also vary according to the type of wetland. Some artefacts are closely associated with specific wet environments. For instance, swords are found more often in riparian hoards (with some exceptions in Scandinavian bogs—see below), whereas tools and other objects are more numerous in bogs. A distinction between ritual and non-ritual deposits has also been attempted. Levy (1982), for instance, describes ritual hoards as having specialized locations (e.g. bogs, springs, wells, etc.) and includes a restricted range of objects (e.g. mainly weaponry, ceremonial objects, food, etc.), which are not usually broken. Non-ritual hoards, on the other hand, have no special location, the assemblage is less stereotypical (e.g. tools, simple objects, etc.) and the objects are both damaged and brand new. This distinction, although useful, is not always applicable, especially considering multiple depositions over long periods, which may alter the stratigraphic chronology of the site. Regardless of the character of the deposition, there are various ways of performing it. It may be a private deposition (only a restricted group of people will experience it), or it may be public, although the person(s) performing it is unknown to the attending group. Or, finally, the deposition may be fully public and all the members attending it know the person(s) performing it (L. Larsson, 2001).

Although there is evidence of Mesolithic depositions (L. Larsson, 2001; O'Sullivan, 2007), they mainly occur from the Neolithic onwards, reaching a peak in the Bronze Age and in particular in the Iron Age. In some areas (e.g. Scandinavia and Ireland) depositions continue up to Viking times (Hedeager, 1999), whereas in other places (for instance, parts of northern and central Europe) they stop (or diminish considerably) after the Romans or during the Early Medieval period.

Apart from small regional differences in terms of objects deposited (e.g. Early Neolithic ceramic depositions in Denmark not occurring in Sweden), the character of depositions, as described above, is fairly ubiquitous all over Europe (especially during the Bronze Age and Iron Age). The number of sites linked in one way or another to wetland votive depositions in northern Europe from the Neolithic to the Medieval period is extremely high. A few of them, thanks to their remarkable assemblages, have contributed greatly to improving our understanding of votive deposition practices (e.g. the depositions in the Hindby bog in Sweden, spanning from the Neolithic to the Bronze Age). A remarkable deposition is the sixteen bronze shields of the Herzsprung

type (*c*.950 cal BC) found in the Fröslunda Bog near Lake Vättern, Sweden (Hagberg, 1988). Some deposition sites contain different forms of sacrifice; from single or small group depositions to large quantities of war booty offered to the gods as thanksgiving by the victors. An example that contains all these forms of offering is the Iron Age site of Skedemosse (on the Island of Öland, Sweden), which, in addition to a large quantity of weaponry and human and animal bones, also yielded seven gold arm rings weighing 1.2 kg in total (L. Larsson, 1998). Similar depositions are also found at Llyn Cerrig Bach (*c*.third century cal BC) in Wales, and at Illerup (Scandinavian Late Iron Age) in Denmark (Coles and Coles, 1996). The spoils of war often include boat offerings. One of the best examples is the three boats of Nydam (Denmark); one of which (the oldest, *c*.AD 200) was completely chopped up before the pieces were deposited in the bog, whereas the two later ones (*c*.AD 300–350) did not undergo that treatment (Rieck, 1999). The Hjortspring boat (the oldest waterlogged boat in Scandinavia—fourth century cal BC) is also believed to have been part of a ritual offering. As pointed out above, pottery, weaponry, and boats were not the only offering items, agricultural tools and personal belongings (e.g. shoes, combs, etc.) were also deposited. Examples of such depositions are the wooden beehive from Edewechterdamm in Germany, the numerous wooden wheels and hubs from Rappendam (Denmark), or those of the Drenthe region (spanning from *c*.2800 to 400 cal BC), and the Bronze Age shoes from Nieuw-Buinen and Barger-Compascuum 1 in the Netherlands, to mention but a few (Coles and Coles, 1989; Coles and Coles, 1996; Van Der Sanden, 1999).

Depositions in northern Europe continued until the Viking period, and they were still performed in bogs (not only indoors as previously thought) (Hedeager, 1999). Although archaeological evidence is rather scarce, votive depositions in wetland environments also took place in other parts of the world. A place where votive depositions and offerings are quite numerous is the Yucatán peninsula in Mexico. Here, especially during the Mayan period, people used to deposit a variety of objects in the cenotes. The best studied of these assemblages is the Cenote of Sacrifice in Chichén Itzá. In New Zealand, as discussed in Chapter 2 (under 'New Zealand'), despite the vast majority of artefacts being buried in wetland contexts for practical purposes (protection, preservation, and retrieval), objects at only a few sites, such as the Kauri Point combs, were definitely votive depositions (Phillips et al., 2002; Shawcross, 1976; Wallace and Irwin, 2004).

Anthropomorphic and Zoomorphic Wooden Figures

Anthropomorphic and zoomorphic wooden figures are ubiquitous finds in most wetland archaeological assemblages all over the world. Generally speaking, two groups of carved figures can be distinguished: one including

figures used as cult objects or idols and effigies, and the other carved representations used as parts of buildings and/or other wooden structures. The first group is more widespread, particularly in prehistoric and early historical Europe, where a further distinction should be made between plank-shaped figures placed along trackways and believed to have had protective properties, and those naturally shaped, which are associated with offerings. The chronology of wooden figures in Europe is fairly long, spanning from the Mesolithic (the oldest being the figure at Willemstad in the Netherlands), to the thirteenth century AD, although the main concentration is between the second half of the first millennium cal BC, and the first few centuries AD (Capelle, 2003).

Belonging to the first category (plank-shaped) are the two figures (presumably a man and a woman) that stood at the beginning of the famous trackway XLII at Wittemoor, Lower Saxony (see 'Within and Between the Wetlands', above). Wooden figures of the second category are more numerous and are found in various parts of northern continental Europe and the British Isles. One of the most impressive collections of this type (containing more that thirty figures dating from about the Roman period) comes from Oberdorla in Thuringia (Capelle, 2003; Raftery, 1996*b*). Well known also are the fairly tall figures (male and female) from Braak in the Ankamper Moor (Schleswig-Holstein, Germany). The male figure is 2.75 metres, whereas the female measures 2.25 metres, and they both date to *c.*400 cal BC (Dietrich, 2003). Denmark also has a large collection of wooden figurines, with the best known being the man with an exaggerated phallus from Broddenbjerg (from about Roman period), and the sitting man from Rude-Eskildstrup (later Roman period/Migrations period) (Capelle, 2003; Coles and Coles, 1989). In the British Isles and Ireland, the chronology of the wooden figures spans the Neolithic to the Iron Age/Roman period. Some of the best-known examples are the Neolithic figures of Dagenham (England), the Late Neolithic/Early Bronze Age one from Lagore crannog (Ireland), the fairly large Bronze Age carving of Ralaghan (Ireland), and the even larger (but of later date—Iron Age) Scottish figure of Ballachulish. Towards the Middle and Late Iron Age, the figures become smaller again, but more sophisticated and of composite character, such as that of Ross Carr.

From about the same period is the sculpture of Corlea 1 in Ireland (Coles, 1990, 1993; Coles and Coles, 1989, 1996; Raftery, 1996*b*). Of slightly later date (Roman period—*c.*2000 years ago) is the long-discussed figure of Strata Florida in Wales. The provenance of the figure is still unknown, but it must have been imported, since it was made of boxwood, a species not indigenous to Wales at that time (van der Sanden and Turner, 2004).

Wooden figures are also known from other parts of northern Europe, from Les Sources de la Seine (northern France) to the Gorbunovo Moor (Russia), but interestingly enough, apart from one single figure from Wasserburg-Buchau (Lake Feder, Germany), no other votive figures are found within the Circum-Alpine region lake-dwelling tradition. Since preservation in this area

is excellent, and other idols and cult objects of other materials (clay and metal) have been found, it is still unclear why the lake-dwellers did not prefer wood for their cult objects.

Outside Europe, wooden figures as idols and effigies for votive depositions are not very numerous. An exception is Mexico, and more precisely the cenotes of the Yucatán peninsula, during the Mayan period. One of the best-studied cenote archaeological assemblages comes from the Cenote of Sacrifice in Chichén Itzá. Here, in addition to gold, copper, and jade objects, a number of finely carved sceptres and wooden figures for votive offerings have been found (Coggins, 2001).

Wooden carvings not used for depositions, but as artistic sculptures or decorations for houses or other structures are found in various parts of the world. Two of the most fruitful places are Florida (United States) and New Zealand. In Florida, the best wooden sculptures are known from the Late Archaic to the Early Ceramic period (*c*.5000–2500 BP), with remarkable artefacts from Tick Island (e.g. the turkey buzzard), the zoomorphic (e.g. eagle) posts of the funerary platform of Fort Center (Lake Okeechobee) (see 'Mortuary Practices' below), or the skilfully carved and painted masks from Key Marco (*c*.1500–1000 BP) (Bullen and Jahn, 1978; Coles and Coles, 1989; Gilliland, 1989; Macdonald and Purdy, 1982; Purdy, 1992; Sears, 1982). Wooden carvings have also come to light at Ozette, on the Northwest Coast of the United States. In addition to the previously mentioned cedarwood inlaid with sea otter teeth, a number of anthropomorphic and zoomorphic seal-killing clubs are part of the rich archaeological assemblage (see Fig. 4.31) (Daugherty and Friedman, 1983).

Within the Maori wetland *pa*, the majority of wooden artefacts were agricultural tools. However, a characteristic of the Maori *pa*-dwellers (and dryland groups too) was that of decorating parts of the house, such as door lintels and doorsills. Some of the best examples are those of Waitara, Te Rarawa, and Kohika, where also parts of gates and fences were finely carved with anthropomorphic and zoomorphic motives (Johns, 2001; Wallace and Irwin, 2004; R. T. Wallace et al., 2004).

Mortuary Practices

The paucity of archaeological evidence of cemeteries or single burials in wetland environments is in direct contrast with the richness of other archaeological remains. Despite the close relationship with the wetlands, people did not seem to prefer watery contexts for disposing their dead. As is discussed below, evidence varies from place to place. There are, however, areas where the absence is striking. Perhaps the most astonishing mystery is, once again, the Circum-Alpine region lake-dwellings where, despite the hundreds of

Fig. 4.31. Anthropomorphic and zoomorphic seal-killing clubs of Ozette, United States. (*Photograph*: courtesy of Ruth Kirk and Richard Daugherty)

settlements occupied by thousands of people within a 3500-year-long tradition, not a single cemetery or isolated grave has been found. A handful of human bones have, of course, come to light within the excavated villages (Simon et al., 1995), but they were mainly the result of accidents (most commonly fire). It is fairly obvious, however, that the absence of archaeological evidence can in this case not be used as an *argumentum ex silentio*. Hence, the question arises: where did all those people dispose of their dead? There have been attempts to link lacustrine material culture to inland graves, but they have not been particularly successful. Other theories have, of course, been advanced, such as cremation on pyres and disposal of the ashes in the lake. Although extremely difficult to prove archaeologically, this may not be too farfetched, as, still today, Hindu believers wish to be cremated in the sacred town of Varanasi and their ashes dispersed in the water of the Ganges (Salvadei et al., 1997). Or maybe the answer should be sought within the *terramare* tradition (see Box 4.4), where necropolises were placed on higher ground well outside the settlements (Cardarelli and Tirabassi, 1997).

In northern Europe and Scandinavia, the mystery is less puzzling, as, despite a strong link to the wetlands, people used to live on their margins, and therefore, cemeteries and burials were placed in drier terrains. Ironically though, it is from the extensive northern European peatbog that the most astonishing evidence of human remains (e.g. bog bodies) comes. These well-preserved bog bodies did not however have anything to do with funerary practices; the reason why those unfortunate individuals ended up in the bogs

was far more sinister (see 'Bog Bodies', below). Funerary practices linked to wetland contexts are nonetheless present, and the best examples are the dugout burials. In Øgårde (Denmark), for instance, a Neolithic (*c.*2640 BC) dugout canoe was found fixed in place by vertical piles, with a human skeleton nearby. It is believed that the deceased was initially placed in the canoe, but eventually washed out (Koch, 1998, 1999). Similar examples were identified at the Mesolithic sites of Møllegabet II and Dejrø; also note the Bronze Age find of Hove Å in Denmark (Rieck, 2003; Skaarup, 1995). A related funerary practice, although not in a watery context directly, is the 'ship-setting', which consists of a boat-shaped setting of stones with a grave. These kinds of grave are fairly popular in Sweden, especially on Gotland, where some 300–350 sites have been recorded, although less than a tenth have been investigated. The majority measure up to 20 metres long, but a few examples from Gnisvärd reach 45 metres. Some of the best investigated ship-settings are those of Slätteröd 6 in Sweden and Thumby, Schleswig-Holstein, Germany (Capelle, 1995; Strömberg, 1961). Cemeteries in peatbogs and lacustrine environments are not found either. Even at the Iron Age lake village of Glastonbury, despite the efforts of Gray and Bulleid, a cemetery was never located. The closest evidence of the villagers' funerary practices were a few neonatal bodies buried underneath the floor of some houses (e.g. mounds 57, 70, and 71) (Coles et al., 1992; Coles and Minnitt, 1995).

Direct evidence of 'real' wetland cemeteries (e.g. people buried in shallow water, or in moist soft peat) is only found in North America, with the best examples being located in Florida (United States). Amongst the four best-known sites, namely Bay West, Little Salt Spring, Republic Grove, and Windover, the latter is certainly the most famous and the most researched. The Early Archaic mortuary pond of Windover (*c.*7400 BP) is the oldest cemetery of this kind. The dead individuals were wrapped in grass mats, placed in the pond, and fastened to the bottom by stakes (Fig. 4.32).

One hundred and sixty-eight individuals (about 50 per cent adults and 50 per cent sub-adults) have been identified, amongst which 91 crania still contained preserved brain (Doran, 2001*a*, 2002). The water chemical contents and pH have preserved bones and brains but not the skin. Based on the preservation of the brains, the bodies were probably placed in the water within 48 hours of dying. Remarkable handmade, non-heddle loom manufactured fabrics, textiles, and cordage (possibly part of the mortuary practice) were also found (Doran, 2001*a*). The other three above-mentioned pond cemeteries are of later dates than Windover, but do share some similarities. For instance, the technique of fastening the bodies on the bottom of the pond using stakes is noted in all four sites, although at Little Salt Spring (*c.*6800–5200 BP) the later bodies (*c.*5500 BP) were interred in the moist soft peat, because the water of the pond was retreating. Here the bodies were wrapped in grass and placed in extended fashion on biers of wax myrtle (Purdy, 1992). The preservation was good, and, as at Windover, some skulls still contained brain tissue. Only 35

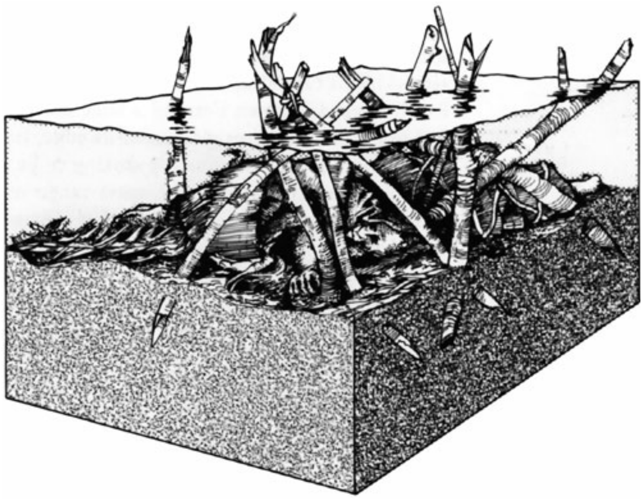


Fig. 4.32. Schematic reconstruction of the way bodies were buried at Windover Pond cemetery, Florida, United States. (Drawn with permission of Glen Doran, Florida State University)

individuals have been removed, but it is believed that about a thousand were buried there. Republic Grove (*c.*6000 BP) yielded a large quantity of fauna and flora remains, as well as a myriad of artefacts (in particular stone beads near a child's neck, believed to be part of a necklace possibly used during the funeral). About 37 individuals were identified and studied. The same number were recovered at Bay West (*c.*6500 BP, although here the bones were very shattered due to severe dredging activity (Beriault et al., 1981; Purdy, 1992). Fort Center, a site of much later date (from 2400 to 250 BP), shows a remarkable way of disposing of the dead. During the second (*c.*1750–1150 BP) of the four occupational phases, the inhabitants of Fort Center built an artificial pond, in which a 20 × 12-metre platform was erected and embellished around its edges with finely carved zoomorphic (eagle, turkey, owl, and duck) totems made of pinewood (Macdonald and Purdy, 1982). The platform was used to place dead bodies after they were wrapped in cloth (Fig. 4.33).

Around 1500 BP the platform burned and fell into the water with all the bodies; some 300 individuals have been identified. Interestingly enough, while bones, wood, and textiles were preserved, flora specimens did not survive (Purdy, 1992; Sears, 1982).

Archaeological evidence of burials in watery contexts such as the above-mentioned Florida sites is not matched anywhere else in the world. But does this really mean that, no matter how close the relationship to the wetlands was, people still prefer to dispose of their dead in drier environments, or is there more than meets the eye?

Fig. 4.33. Schematic reconstruction of the burial platform of Fort Center, Lake Okeechobee, Florida, United States. (After Macdonald and Purdy, 1982. *Drawing*: Gordon Miller)

BOG BODIES

Despite the above-mentioned array of archaeological objects retrieved from wet or waterlogged contexts, the bog bodies undoubtedly remain the most intriguing and mysterious finds. Their remarkable preservation has allowed scholars to identify the most delicate body parts (e.g. skin, internal organs, nails, hair, etc.), which are normally not preserved. This astonishing preservation of bodily organs is mainly found in sphagnum moss-rich peatbogs. It is, however, not, as previously thought, the absence of oxygen and the presence of antimicrobial substances in the sphagnum moss that inhibits decay of the body, but the presence of a polysaccharide (sphagnan) in the sphagnum moss. Once the moss dies, the sphagnan is dissolved but, being an unstable compound, it is converted into humic acid via intermediate compounds. A complex chemical reaction extracts the calcium from the body preventing (or reducing) bacterial growth. At the same time, another series of complex

reactions (also known as 'melanoidin' reaction) reduces the availability of nitrogen for bacteria, facilitating the tanning of the skin (Clément and Proctor, 2009; Painter, 1991, 1995; van der Sanden, 1996). As a result, a delicate balance between the various components determines the final preservation of the body. In peatbogs, for instance, skin, hair, nails, and garments made of wool and leather survive well, but bones and clothes made of plant fibre (e.g. linen) may not. In a fen environment (which is more calcareous) on the other hand, bones and plant fibres are usually preserved, but the rest is not (see also the 'Preservation' section in Ch. 5).

Because of these different levels of preservation, bog bodies may be divided into two categories; those with perfectly preserved skin and internal body organs (but not bones), and those with bones (and sometimes brain), but not the rest (see e.g. Windover). Bog bodies of the former category are found mainly in northern Europe (see Fig. 4.34), whereas a large number of the latter have come to light in Florida, United States.

Because of the delicate balance between the various preservation factors (e.g. chemical compounds, climate, deposition, and period) a mixture of preservation levels may also occur; one of the best examples is the Tollund Man, with skin, bones, internal organs, leather clothes, and even brain outstandingly preserved (Fig. 4.35) (van der Sanden, 1996).

More than the remarkable preservation of body parts, the fascination about the northern European bog bodies is the mysterious and sinister way that they met their death; some of them were strangled, hanged, stabbed, and even beheaded. As a result, a myriad of theories as to how those unfortunate individuals met their fate have been developed in the last hundred years or more. Glob (1969), for instance, believed that the majority of bog people were sacrificed, whereas German scholars have been more cautious with their explanations, arguing that each case must be considered separately in its own specific context. Hence the need for more multidisciplinary research and reconsideration of old discoveries. It was with the discovery of the Lindow bodies (especially II and III) that the attitude towards their interpretation started to change (Turner, 1995; Turner and Scaife, 1995). Some bodies such as the Yde Girl, the Weerdinge couple, and the Zweeloo Woman, were re-examined and important medical pathologies identified (e.g. the Yde Girl suffered from scoliosis, and the Zweeloo Woman had extremely short forearms). Other bodies were even linked with neighbouring cultural groups (e.g. the Emmer-Erfscheidenveen Man's clothing was similar to that of the occupants of the contemporary Danish trunk-coffins) (van der Sanden, 1996). A few more famous bog bodies revealed further details which had hitherto been unknown. For instance, the Iron Age Kayhausen Boy turned out to be younger (7–8 years old) than previously believed; and it was discovered that Roter Franz (Roman period) was probably a horseback rider, had a broken

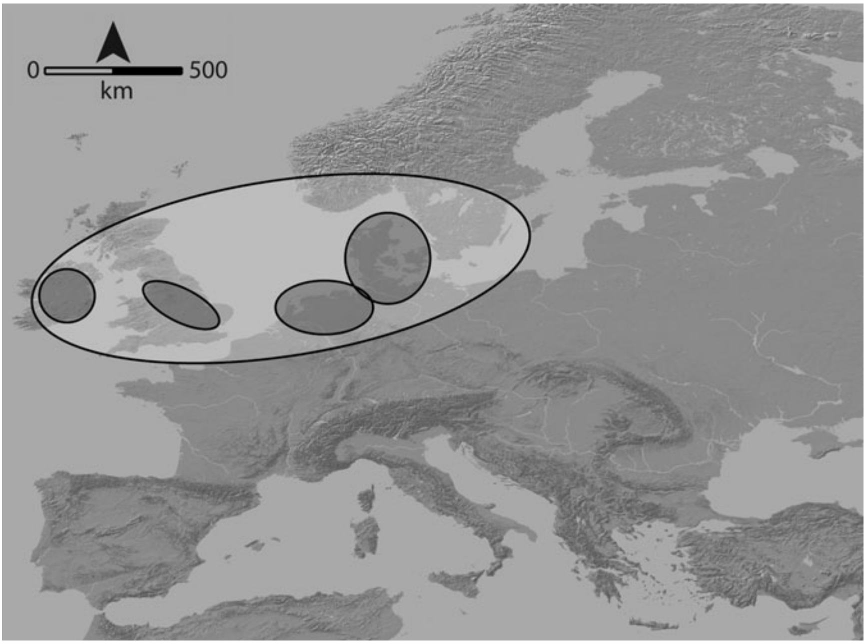


Fig. 4.34. Area of bog bodies in Europe. (*Graphic*: Ben Jennings. Base map created using STRM data and ArcWorld River and Lake Overlay)

arm and broken collarbone, and was probably killed by having his throat cut (Pieper, 2001, 2003; Pieper et al., 1999).

Re-examination of well-known bog bodies has also contributed to lessen biased assumptions. The Grauballe Man (*c.*400–200 cal BC to Roman period) for instance, was confirmed to have been suffering from arthritis attributable to ergot, but the ergot sclerotia were too small to have affected his mental state (Asingh and Lynnerup, 2007). The Weerdinge couple, previously thought to be a man and a woman, turned out to be two men. But the most astonishing and unexpected result concerns the famous 14-year-old Windeby Girl, who, because of Tacitus' writings (in his *Germania*) was believed to have committed adultery. Careful examination, however, revealed that the bog body was that of a 17-year-old boy (Gebühr and Eisenbeiss, 2007).

Some reconsiderations of bog bodies, although still yielding fascinating results, have been, scientifically speaking, inconclusive. The best examples are the decapitation of Rendswühren Man and Dätgen Man, and the removal of Rendswühren Man's penis; in neither case was it possible to determine whether the acts were ante-, peri-, or post-mortem. Even recently found bodies may present divergent interpretations, which in some cases are linked to different archaeological research traditions. For instance, reflecting the more cautious interpretative scheme of German scholars, the death of

Fig. 4.35. The Tollund Man's face (*Photograph*: courtesy of the Silkeborg Museum, Denmark)

Moora, the Iron Age (seventh-century cal BC) girl from Uchter Moor (Lower Saxony), was considered an accident rather than a sacrifice (Bauerochse et al., 2008). On the other hand, the Irish Clonycavan Man (Co. Meath) and the Old Croghan Man (Co. Offaly) (*c*.300 cal BC), have been more audaciously interpreted as sacrifices linked to tribal boundaries (E. Kelly, 2006). Although daring, the latter interpretation opens new perspectives for further analysis. Evidence that hints to other possible interpretations of bog bodies comes from the two individuals reburied under the floor of the Cladh Hallan Bronze Age house on the Hebridean island of South Uist (Scotland). Not only were the two 300–500-year-old bodies dug up from the bogs, but they were made up from different individuals (one from two individuals, and the other from three) (Parker Pearson et al., 2005, 2007).

These last three examples show how important it is to contextualize the finds in their surrounding environment (nearby settlements, location of the bogs, etc.). Contextualization rather than generalization is the way forward for future bog body research. This may render the bog people less mysterious and intriguing, but it will certainly avoid biased interpretations, which, in the long run, may compromise and spoil our understanding of prehistoric societies.

CONCLUSION

The overwhelming amount of archaeological evidence, from entire settlements to microscopic plant remains, needs a systematic classification in order to appreciate its value and diversity. The richness of some assemblages and the paucity of others is not always the result of good and bad preservation. Geographical as well as cultural factors are, for instance, to be taken into account if one wants to be able to explain the difference between prehistoric lacustrine villages in the Circum-Alpine region and the (at times) contemporaneous crannogs in Scotland, island settlements in Poland, and the *terramare* in northern Italy. Long-distance trade and local exchange are better understood when the various means of transport, as well as the permanent communication networks (rivers, canals, paths, and wooden trackways) are considered in different spatial/temporal scales. The ubiquity of a vast range of wooden artefacts and agricultural tools certainly goes beyond a simple environmental deterministic explanation. A typical example is the regional diversity of basketry on the Northwest Coast of North America, where cultural differences (or similarities) can be detected through space and time according to the diverse basketry typology. Weirs and fish-traps can go a step further, allowing archaeologists to identify not only different economies, but also ancient fishery management, in relation to seasonal availability.

Because of their mysterious character, gloominess, and inaccessibility, wetland environments (especially the northern European peatbogs) have always been considered boundaries between physical and spiritual worlds. As a result, a number of activities ranging from offerings to various kinds of sacrifice were performed around and within them. Surprisingly though, the European as opposed to North American (see Windover, for instance) wetlands were never used as cemeteries. In the Circum-Alpine region, for example, despite the large number of lakeside settlements, spanning more than 3500 years, not a single burial ground was ever found in a waterlogged context. This is not to say, of course, that no mortuary practices were performed on the lakes. As discussed, there is in fact the possibility that those practices left no recognizable archaeological evidence. On the other hand, traces of sinister activities (human sacrifices, executions, etc.) are clearly evident in the northern European peatbog, in the form of well-preserved human corpses (bog bodies). The majority of these bog bodies show evidence of a terrible death (hanging, decapitation, throat cutting, etc.); hence, a number of theories as to how they met their death have been formulated. There is no doubt that some of those people were victims of sacrifices or executions, but it is incorrect to assume that all of them died in that way.

As discussed throughout the chapter, the amount and richness of archaeological evidence found in waterlogged sites is overwhelming. It is therefore crucial that protection, recovery, and conservation fall within well-planned parameters. This will lead to a more systematic and contextualized way of studying our cultural heritage, avoiding biased generalizations (see Ch. 5).

5

In the Field and Beyond: Survey, Excavation, Preservation, and Conservation

INTRODUCTION

Field methods (including survey, excavation, preservation, and conservation) are probably some of the very few aspects of wetland archaeology that should be considered separately from ‘conventional’ archaeology. Detecting archaeological organic material buried in waterlogged conditions is not always straightforward. Since the nineteenth century, the discovery of most wetland archaeological sites has been (and still is) made by chance (see e.g. Flag Fen, the Sweet Track, Star Carr, Windover, and many more) (Coles and Coles, 1996). Unfortunately (or maybe fortunately), even large structures (e.g. houses or trackways) are made of organic materials (mainly wood), which in waterlogged conditions become extremely soft, hence acquiring a consistency equal to the matrix (soil or peat) around them. As a result, conventional geophysics survey devices (e.g. Ground Penetrating Radar—GPR) is ineffective for detecting them. However, the need for more non-destructive survey methods has encouraged researchers to develop new techniques, such as the Swath Bathymetry Sonar (SwBS) for underwater survey, and Spectral Induced Polarization (SIP) for waterlogged terrains, which, used in conjunction with more conventional techniques (e.g. auger survey, aerial photography, Electromagnetic Survey (EM), Multi-Spectral Scanning (MSS), Magnetic Susceptibility Survey (MS), and Caesium Vapour Magnetometer), have proved to be fairly effective in wetland archaeological survey (C. Cox, 1992; Gostnell, 2005; Weller et al., 2006).

It is clear that because of the peculiarity of wetland environments and their delicate waterlogged organic remains, excavation techniques are substantially different from those of conventional dryland archaeology. It is therefore crucial to distinguish between excavation methods, even within wetland archaeology itself. Methodologies and techniques vary significantly, especially in heavily waterlogged or underwater environments. The various water-saturated terrains require different excavation approaches, which depend

upon the morphology, hydrology, and the composition of the soil sediments in which the archaeological remains are buried. This chapter discusses a number of excavation methods, from the suspended walkways and scaffolding structures used in peatbog excavations (Coles and Coles, 1986; Schlichtherle, 2002, 2004), to the cofferdam (also known as caisson) technique adopted in lacustrine or river-bank digs (Ramseyer, 1988; Zwahlen, 2003). Because of the fairly large number of currently submerged archaeological sites, a special emphasis is placed upon the various underwater excavation techniques used in lakes and other freshwater basins. In particular, the attention is drawn to the state-of-the-art water-jet pipe technique as opposed to the more conventional vacuum method (Hafner, 2004; Eberschweiler, Hafner and Wolf, 2006). The former is more suitable for compact clayish lake marl, whereas the latter is normally used with much softer sediments. Finally, the germane aspect of the pre- or during-excavation collection of scientific samples (coring, vertical/horizontal bulk-sampling, and sieving), is examined within each of the discussed digging techniques (see also Ch. 6).

Preservation and conservation processes are also part of a successful wetland archaeological excavation campaign. What has been preserved by nature for a very long time can be destroyed in the blink of an eye. Although prevention is better than cure, sometimes the destruction cannot be avoided. Hence, the chapter shows not only how to prevent the worst, but also how to put it right. The terms 'preservation' and 'conservation' occur quite often in wetland archaeology, and quite often they are misused. Despite the fact that they are intricately entangled, they have different meanings. Very broadly, preservation occurs before the archaeological site is even touched, whereas conservation takes place afterwards, to prevent decay. It is quite obvious, though, that in the long run conservation will never be possible without prior preservation of the environment. Since it is not often known what lies beneath the surface, it is difficult to ascertain where preservation processes should be undertaken. However, research on preservation techniques in wetland environments has progressed quite substantially in the past two decades, and a variety of methods have been developed. This chapter discusses the major preservation techniques according to the different wetland environments; from stabilizing the water-table (redox potential), used in waterlogged terrains (marshlands, swamps, peatbogs, etc.), to anti-erosion measures (geotextile blankets, protective enclosure geo vegetational management, etc.), applied on lake shores, river banks, and coastal areas (Cox et al., 1995; Hafner et al., 2006; Ramseyer and Roulière-Lambert, 2006).

The final part of the chapter focuses on post-excavation conservation techniques. Although a general overview of all the most common methods used with different materials is presented, a special emphasis is placed upon the polyethylene glycol (PEG) technique. Different percentages of PEG solution used for pre-soaking treatment (one- and two-step impregnation) are

discussed in conjunction with the various drying techniques: from freeze-drying to air-drying, including the latest research on the supercritical drying method (Kaye and Cole-Hamilton, 1998; Wahlbrink et al., 2006), in order to see which one is more suitable for the diverse species of wood and/or morphologies of artefacts.

SURVEY

The vast majority of wet/wetland sites have been discovered serendipitously. This is mainly due to two factors: first their lack of visibility and accessibility, and second the difficulty of detecting them within the environment. Visibility, or the extent to which an observer can identify archaeological material at or below the surface of a given place (Schiffer et al., 1978), varies considerably within wetland contexts; from high (e.g. wooden pile structures on a lake shore), to low or non-existent, in a peatbog. Visibility also includes obtrusiveness, or the ease with which material culture produced by people can be identified by archaeologists. As the majority of settlements (or sites) within a wetland environment are made of wood (and are therefore more prone to deterioration), they are less obtrusive than more durable stone buildings. Cultural factors play an important role too; for instance, sedentarines mobility vs. sedentism, or seasonal vs. permanent settlements, also contribute to higher or lower degrees of obtrusiveness. An additional factor that has to be taken into account is accessibility. Wetland areas are notoriously difficult to reach and therefore to survey. Complicating the situation even further is the material (mostly wood) used to build dwellings and create artefacts. In fact, archaeological objects and structures made of wood become almost impossible to detect within a waterlogged peat matrix, even with the most sophisticated GPR device (there are a few exceptions though, see below). As a result, the most effective survey methods in wetland environments still remain the conventional invasive ones, such as sub-surface testing, including test pit digging and coring/augering. Test pits may vary in size, from the removal of a few cubic centimetres of soil to fairly large but narrow trial trenches. This type of survey is usually done in peatbogs, semi-wet swampy areas, and high water-table fields, and it is better if archaeologists already have a fairly good knowledge of the area, or if other sites have been discovered nearby. If, on the other hand, the area is unknown and the potential sites are presumed to be relatively deeply buried, coring with hand or mechanical augers is preferred. The positive outcome of such a survey depends upon various factors, from the size of the area to the intensity of the auger points within a given grid. The selection of a suitable sampling strategy is also very important. Four types are normally used: (*a*) simple random, (*b*) systematic random, (*c*) systematic

aligned, and (*d*) stratified random (Fish and Kowalewski, 1990). However, the type of wetland that archaeologists are dealing with also influences the choice. For instance, the morphological structure of some wetlands (e.g. very humid fens) would not allow a straightforward systematic random grid; simple random or stratified random methods would be more appropriate. In some cases where surface visibility is good (e.g. wooden piles on lake shores), field walking the area can be of great help. Finally, since wetland environments are often linked to local mythologies and beliefs, historical and ethnographical sources and local informants are certainly useful to consult before planning or carrying out a survey.

Remote Sensing

Remote sensing identifies archaeological features beneath the surface of the ground without removing the soil. Any disturbance (anomaly) that differs from the soil matrix can potentially be detected by a number of geophysical instruments, by means of procedures divided into two different categories: passive and active. Amongst the former are the magnetic survey techniques, such as the proto-magnetometer (a device that measures the earth's magnetic field at the surface), whereas active procedures include acoustic and seismic sounding, electromagnetic methods, resistivity surveying, and GPR. Although the latter techniques are undoubtedly the most widespread and applied ones, they have serious limitations within wetland environments. GPR works best when there are abrupt rather than subtle discontinuities in the electrical properties of the subsurface (Weymouth, 1986) (see also Fig. 5.1).

Since archaeological remains in wetland contexts are mainly of organic material (e.g. wood), these discontinuities become an integrated part of the matrix (waterlogged soil or peat) and they are extremely difficult to detect. This should not, however, discourage archaeologists as promising results can be achieved even with some of the above-mentioned standard GRP methods (Armstrong, 2010). New methods able to distinguish between the electrical properties of different materials (wood, soil, peat, etc.) are, however, being developed with promising results. One of them is the Spectral Induced Polarization (SIP).

Spectral Induced Polarization (SIP)

The non-invasive SIP survey technique measures the frequency dependence of conductivity amplitude and the phase shift (which is related to polarization effects of the different materials) between injected current and resulting voltage signal. Different materials show different variations in the spectra of conductivity amplitude and the phase shift. Hence, characteristic features of

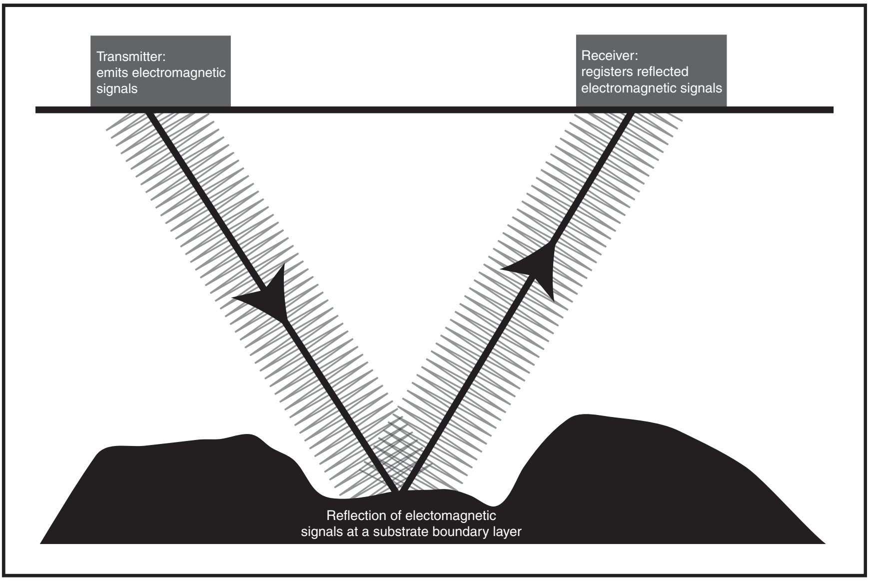


Fig. 5.1. Principle of ground penetrating radar (GPR). (*Graphic*: Ben Jennings)

the phase spectra can be used to identify wooden relics within semi-waterlogged or waterlogged wetland environments, such as peatlands (Weller et al., 2006). The technique has been successfully applied in two instances; the identification of buried trackways in the Campemore bog (northern Germany) (Bauerochse, 2001), and around Lake Feder (Schleifer et al., 2002). Although in ideal conditions the method is considered to be fairly reliable, it has some limitations. For instance, oak and birch sample results are difficult to detect, as the former presents a too-wide phase minimum between 1 and 10 Hz, whereas the latter has a too-low polarization effect. Moreover, it seems that, in general, wooden remains are better identifiable if they are not too deeply buried in peat deposits (Weller et al., 2006: 123). It is therefore suggested that the SIP method be used in conjunction with GPR, as the latter is more suitable for the identification of materials other than wood, as well as being able to map the morphology (e.g. depth and other natural geological anomalies) of the peatbog.

Aerial Photography

A too-small vertical scale or a too-large horizontal one may not permit recognition of cultural features, whether lying on the surface or beneath it. In this case a bird's-eye view may be useful to discern subtle change in elevation, vegetation colour, or growth patterns. Aerial survey includes air photography (also satellite imagery), thermography, and radar imaging. Aerial

photography, with a special emphasis placed on infrared imaging, is used to detect differences in the amount of heat being reflected off vegetation in waterlogged environments, allowing researchers to spot surface anomalies linked to peat thickness and/or semi-buried waterholes. A precise mapping of an area would not only increase the potential of locating buried archaeological remains, but also facilitate the planning of a systematic sampling strategy. Aerial photography has been applied successfully in various wetland archaeological surveys, from riparian and lacustrine contexts to peatland, and even for the identification of pre-Columbian agricultural field systems in Central and South America. Within a lacustrine landscape context, aerial photography was first applied by Paul Vouga to identify the layout of the Cortaillod pile-dwelling on Lake Neuchâtel in the 1920s (see Fig. 5.2). Since then, tens of lakeside settlements have been recorded and studied in this way (Schlichtherle, 1997*b*). The technique is still very much in use today, and not only in the Circum-Alpine region. Harding (2007) has applied it recently to identify crannogs and island duns in the Scottish lochs.

Laser and radar techniques can go a step further, as has been shown by Adams et al. (1981), who, using a device known as Side-Looking Airborne Radar (SLAR), were able to identify Maya raised fields and canals within a dense vegetation context. High-resolution GPS survey in conjunction with GIS surface interpolation and modelling has also proved to be a successful

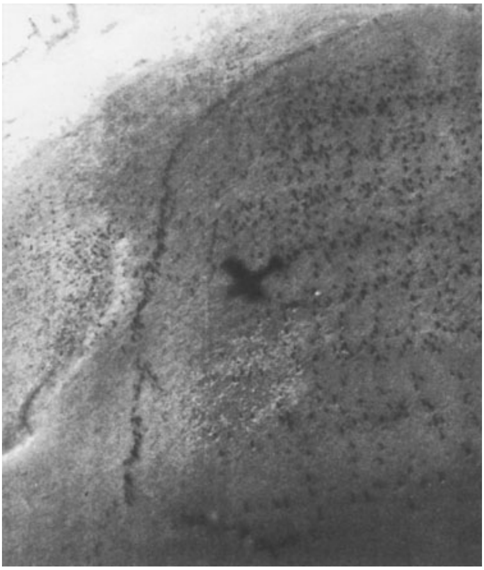


Fig. 5.2. Aerial photograph taken by Paul Vouga at the Cortaillod pile-dwelling on Lake Neuchâtel, Switzerland, in the 1920s. (*Photograph*: courtesy of Marc-Antoine Kaeser, Laténium Museum, Neuchâtel, Switzerland)

prospecting technique able to identify buried archaeological features in wetland environments (Chapman and Van de Noort, 2001; Van de Noort et al., 2001). Micro-topographical features linked to the differential desiccation of biogenic and minerogenic sediments are identified by using a Real Time Kinematic (RTK) differential Global Positioning System (dGPS), which, thanks to radio signals transmitted from a constellation of up to twenty-four satellites, is able to reach centimetric accuracy. The data are then elaborated in Geographic Information System (GIS) to obtain a representation of the surface that could be either contour bands or an elaboration of virtual light sources to emphasize the relief (in particular slopes). The technique has been successfully applied on two sites: at Sutton Common (Humber wetlands), and at Meare Village East (Somerset Levels) (Chapman and Van de Noort, 2001; Van de Noort et al., 2001), and is becoming an integrated part of wetland preservation projects in various parts of Europe.

Underwater Survey

A large quantity of archaeological evidence in wetland contexts lies in water (buried in underwater marine, lacustrine, and riverine sediments), hence making the evidence even more difficult to detect than that in peatlands and/or water-saturated terrains. As a result, marine geophysical methods have become an indispensable part of underwater survey. While electromagnetic waves are more widely used on land, underwater sound is preferred, as it is a mechanical wave and suffers less attenuation in water. Two types of acoustic system are distinguished: the profiling methods emitting a single vertical beam, and the swath methods emitting a fan of beams to the side of the system. These two types are themselves subdivided into two further categories: the profiling methods include single-beam echo sounders (SBES), and sub-bottom profilers (SBP). An SBES system emits a high-frequency narrow beam vertically below the surface. It is fairly simple to use, but does not provide full coverage of the sea floor. The SBP, on the other hand, emits lower frequency beams that penetrate the seabed and identify material in it. Swath methods also include two different techniques: Side-Scan Sonars (SSS) and Swath Bathymetry Sonars (SwBS). The latter in particular is widely used; it can map relatively large areas in great detail and in a relatively short time (see Fig. 5.3). It is still expensive, however, and requires experienced personnel to operate it (Gostnell, 2005).

One major problem with all these techniques is that they may not be fully reliable in shallow water (e.g. because of logistic over-saturation of the returned signal, interference with other acoustic sonars, etc.). A good solution is the application of non-acoustic systems such as the newly developed bathymetric LiDAR (Light Detecting And Ranging) technique, which uses laser rays at different wavelengths. A great advantage of this system is that it can operate in very shallow water. However, because of its sensitivity to aerosol and cloud

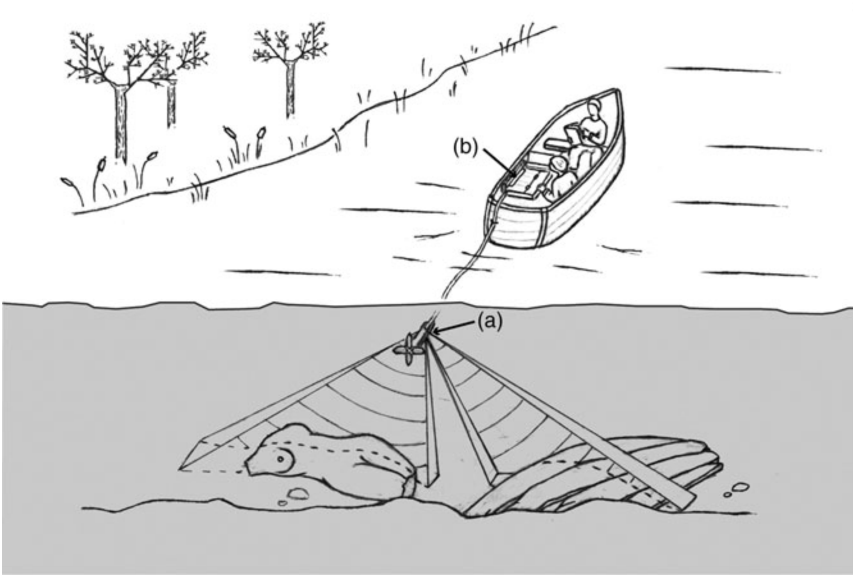


Fig. 5.3. Schematic representation of the Swath Bathymetry Sonar (SwBS) towed by a boat with reading and mapping devices on board. a) Sonar device; b) data plotter. (*Drawing*: Olenka Dmytryk)

particles in the atmosphere, the technique is fully reliable only in relatively clear water and fair weather. Another solution for shallow water environments is the adoption of GPR. In fact, Moorman (2001) has demonstrated that GPR normally used for terrestrial survey can also be effective at mapping bathymetry in shallow freshwater areas, with a further possibility of using it on frozen lake or river surfaces. GPR does not work in salt water, and therefore it cannot be used in estuary environments, where a joint application of SBES and SSS produces reliable results at a depth of less than 2 metres (Sonneburg and Boyce, 2008).

As on land distinguishing between natural and manufactured objects under water, is a major challenge. Lawrence and Bates (2002) argue that it could be possible to distinguish between underwater wooden and steel wrecks. Further research showed that wooden objects have a large negative reflection coefficient (Bull et al., 1998) that changes as the wood degrades (Arnott et al., 2005). In fact, it was subsequently proved that wood appears as a distinct negative reflector on the seismic data, and the reflection coefficient becomes more and more negative as degradation increases (Plets et al., 2008).

From the various survey methods discussed above it has become apparent that wetland archaeological research is no longer satisfied with leaving discovery and cultural heritage management to chance. More and more techniques

are being developed and perfected, which along with the help of predicting models for locating and mapping new archaeological sites (Chapman and Cheetham, 2002; Chapman and Gearey, 2002; Engen and Spikins, 2007), will lead wetland archaeologists to new research perspectives. The challenge is greater than on conventional terrestrial sites, but encouraging positive results have shown that non-invasive survey techniques are invaluable and soon unavoidable tools to researching, managing, and protecting our wetland natural and cultural heritage.

EXCAVATION

Although they follow the same concept, wetland archaeology techniques differ substantially from those used in conventional dryland sites. The diversity of wetland environments forces wetland archaeologists to use different methods to suit the morphology, soil composition, and, in particular, the hydrology of the various waterlogged terrains. As a result, peatland excavations are, for instance, slightly more diverse than those carried out in semi-waterlogged lacustrine and river-bank areas, or those in aquifer sediments. Not only do the techniques change from one environment to the other, but also the tools and equipment used could be different (e.g. trowels, spatulas, pumps, dewatering systems, etc.). In some cases the preliminaries (e.g. setting up the equipment, building cofferdams, and dewatering the area) may take longer than the excavation itself. Underwater excavation requires even more attention and preparation, but the results can be very rewarding. The richness of the well-preserved organic materials found in wetland excavations allows a profusion of scientific analyses. Hence the importance of a systematic sampling strategy that, once again, may vary according to the excavation techniques used and the various types of terrain excavated. Waterlogged terrain and underwater excavations can be very time-consuming and expensive. It is therefore crucial to plan them well in advance and take into account all possible variables in order to avoid unexpected surprises that may jeopardize the entire project.

Peat and Semi-waterlogged Terrain Excavations

A number of crucial factors have to be taken into account when planning to excavate an archaeological site in peat or semi-waterlogged terrains: (*a*) the size of the site (if known), (*b*) the hydrology (does the site need a complex dewatering system?), (*c*) the kinds of archaeological remains that are likely to be found, and finally (*d*) the structure and size of the excavated area. Large-scale dewatering operations using semi-complex networks of wellpoints are

not commonly used in Europe. In the United States, on the other hand, this method is more widely applied. At Windover, for instance, a series of over 150 wellpoints were installed to dewater the area, and allow the excavation of the *c*.8,000-year-old pond cemetery (Doran, 2001*b*, 2002) (see also Ch. 2, under 'North America', and Ch. 4, under 'Mortuary Practices'). The wellpoint dewatering technique is fairly straightforward, and consists of driving long cylinders (the diameter depends on the number of wellpoints and the capacity of the vacuum pump) into the ground around the excavated area. Through a header pipe, the wellpoints are connected to a pump that vacuums the excess water and discards it into another area away from the site. Because of the smaller and shallower excavated area, as well as a different hydrology, peatland excavations in Europe do not usually require complex dewatering systems. There are, however, examples where small combined dewatering and watering systems are installed around the excavated area. This technique consists of a header pipe built around the perimeter of the excavated trench (unit), and connected to a series of wellpoints, which are driven into the ground, just inside the trench. The header pipe is then linked to a pump, which vacuums and/or pumps (double function) water from and to the site as needed. The control valve (or tap) placed on top of each wellpoint regulates

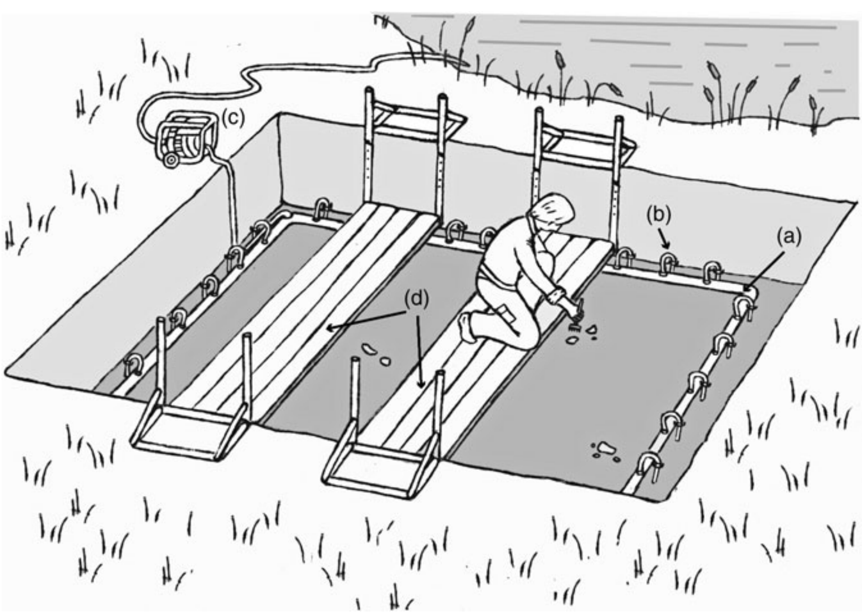


Fig. 5.4. Schematic representation of an excavated area in semi-waterlogged terrain with a dewatering/watering system installed around the perimeter. a) header pipe; b) wellpoint and regulating valve; c) pump; d) suspended adjustable steel-framed plank-walks. (*Drawing*: Olenka Dmytryk)

the intake or outlet of water in different parts of the excavated areas according to different needs (Fig. 5.4b).

The advantage of this technique is that it can eliminate the excess of water shortly before the excavation begins, or reflood the area when excavators are not working (e.g. during the night), thus avoiding the use of polythene sheets or other protective measures. This technique works best in wet areas near rivers, lakes, ponds, and other water basins, which allow an easy intake and discard of water. An example of a successful application of this method is the excavation of the La Draga Neolithic lake-dwelling on Lake Banyoles, Spain (Bosch et al., 2000, 2006). If the dewatering system is not available and the area is fairly wet, it is advisable to have a section of the excavated area lower than the rest (e.g. a step-trenching system) functioning as a sump. Here the excess of water can easily accumulate and can be eliminated later, without interfering with the archaeological remains.

Due to the extremely soft and delicate deposits (matrix and archaeological remains), movement within the excavated area is restricted and usually limited to suspended plank-walks. If the excavated area is not too large and archaeological remains not too deep, simple wooden planks can be placed across the unit (Fig. 5.5). As the trench becomes too deep to reach, suspended adjustable steel-framed plank-walks are adopted (Figs. 5.4 and 5.6) (Schlichtherle, 2004).

Not only are these steel-framed plank-walks more stable and secure, but they also allow the excavator to work as close as possible to the archaeological remains. In some cases, if the predisposition of the archaeological remains

Fig. 5.5. Series of modern plank-walks placed on wooden boxes used at the Sweet Track excavation, Somerset Levels, England (© Somerset Levels Project—John and Bryony Coles)

Fig. 5.6. Suspended adjustable steel-framed plank-walk used at Bad Buchau-Torwiesen, Lake Feder, Germany. (Photograph: Wolfgang Hohl, courtesy of the Landesamt für Denkmalpflege, Baden-Württemberg, Germany)

allows it, toe-boards (pieces of wood the size of a bread-board) can be used to support feet, knees, or elbows in order to get closer to the artefacts in a more comfortable position (Fig. 5.7) (Coles, 1984; Coles and Coles, 1986).

If the excavated area is extremely large (e.g. the surface of an entire prehistoric lacustrine village), a web of scaffolding is constructed over the site (Fig. 5.8), within which adjustable plankways can be placed. A good example of scaffolding structures to access a large village layout is that of Hauterive-Champréveyres, Lake Neuchâtel (Egloff, 1980, 1981, 1987, 1988).

Because of the sediments and delicate artefacts, sharp metal tools are not allowed in wetland excavations as they could damage the objects irreparably. Wooden chopsticks, spatulas, or small spoons are used instead. However, the best excavation tools remain bare fingers. Hand spray bottles are also sometime used to clean the artefacts *in situ* before their removal. Once the objects are exposed, they are instantly in danger of desiccation or warping, therefore they must be kept constantly moisturized. A good way to achieve that is the use of watering cans and polythene sheets throughout the excavation. Large projects even set up sprinkler systems and other more sophisticated measures (see below).

Object recording and measuring in peatland excavations can sometimes be tricky. Although electronic theodolite/total station 3D recording is today a fairly standard practice, other more conventional measuring techniques are

Fig. 5.7. The use of toe-boards at the Sweet Track excavation (© Somerset Levels Project—John and Bryony Coles)

Fig. 5.8. Scaffolding structures and walkways over the Late Bronze Age lake-dwelling site of Hauterive-Champréveyres, Lake Neuchâtel, Switzerland. (*Photograph*: courtesy of Béat Arnold, Office et Musée d'Archéologie, Laténium Museum, Neuchâtel, Switzerland)

still used. One difficulty is the lack of stable ground (in some areas the peat surface can fluctuate up to 10 cm in only a few days). A firm reference point has therefore to be located outside the peat, and, if not too far, the measurement point shot from there. Once the reference point is established, manual measuring is usually done with a tape measure and water/hose levels. Photography is also a crucial part of wetland excavation. It often happens that large structures (e.g. house floors, trackways, etc.) cannot be fully conserved, hence the importance of photographing them in their full extent. This can be done by composite photo-mosaics, or air (or gas) balloon photography, whereby a camera is attached to an air/gas balloon and guided by a rope from the ground. When the right height is reached (depending on the size of the site), the photo is taken with a remote control device. The technique was first applied to a wetland excavation in Biskupin (Poland) in the 1930s (see Fig. 5.9) (Piotrowski, 1998), and has been successfully used ever since.

One of the crucial aspects of wetland excavations is the sampling strategy for further scientific analysis. As pointed out above and stressed in Chapter 6, the large amount of well-preserved organic material available in wet/wetland

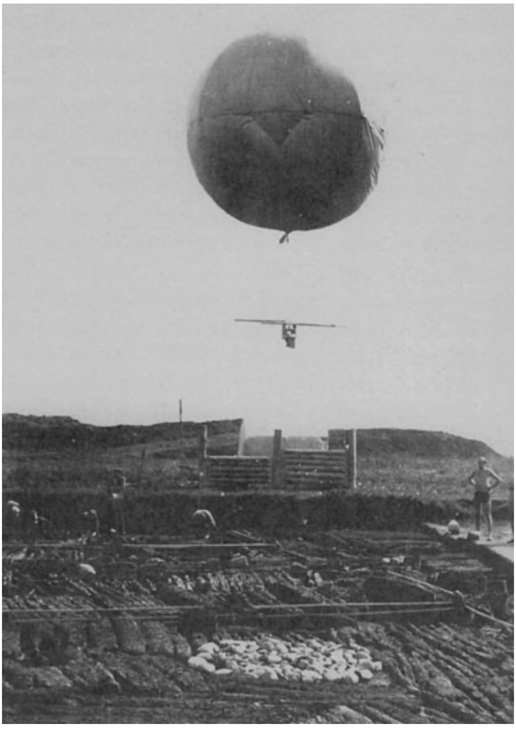


Fig. 5.9. Air-balloon photography at the wetland site excavation of Biskupin (Poland), in 1936. (*Photograph*: courtesy of the Biskupin Archaeological Museum, Poland)

sites allows a profusion of multidisciplinary-based scientific analyses, and as a result, an effective sampling strategy is imperative. Although the same sample can often be used by different disciplines (e.g. archaeobotany and geoarchaeology), each one may want to have its own particular samples that suit the discipline better (e.g. cores, columns, surface samples, Kubiena tins, etc.). It is therefore important that the sampling strategy is planned well in advance, before the excavation begins. Finally, water sieving of the removed soil/peat (matrix) should be an essential integrated part of each wetland excavation.

Cofferdam (Caisson) Excavation Technique

Wetland sites are sometimes located in shallow water (rivers, coastal areas, or lacustrine morainic shoals), which is not deep enough for underwater excavation. In this case, a cofferdam, consisting of double-walled interlocking steel plating driven into the inundated sediments (Fig. 5.10), is built around the area and water is vacuumed out completely, transforming the underwater site into a semi-wet site that can be excavated using the techniques described above.

The first application of cofferdam excavation dates back to the 1920s, when Paul Vouga placed a 3-metre high and 1.5-metre diameter metal cylinder over a section of a prehistoric lake-dwelling located in the shallow water of Lake Neuchâtel. By vacuuming out the water inside he was able to collect some artefacts from the bottom of the lake (Hafner, 2004). A few years later (1929), Reinerth applied this technique at Sipplingen (Lake Constance) by building a

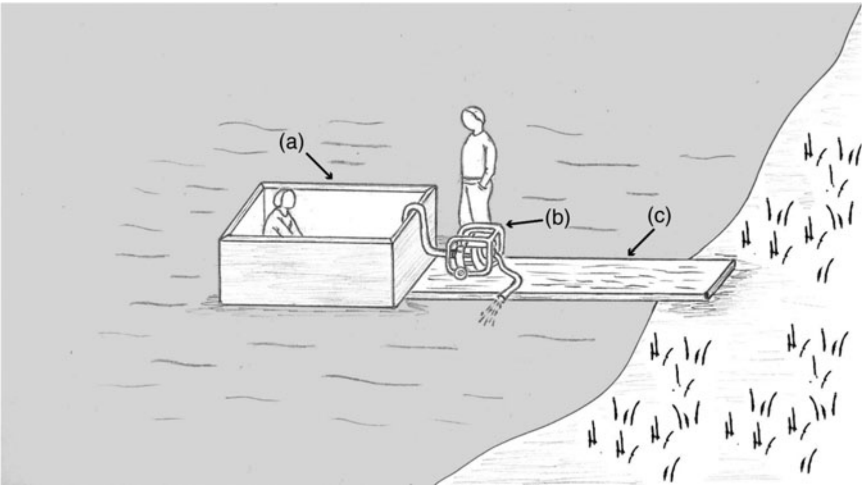


Fig. 5.10. Schematic representation of the cofferdam technique: a) cofferdam; b) pump; c) wooden plank walkway to the shore. (*Drawing*: Olenka Dmytryk)

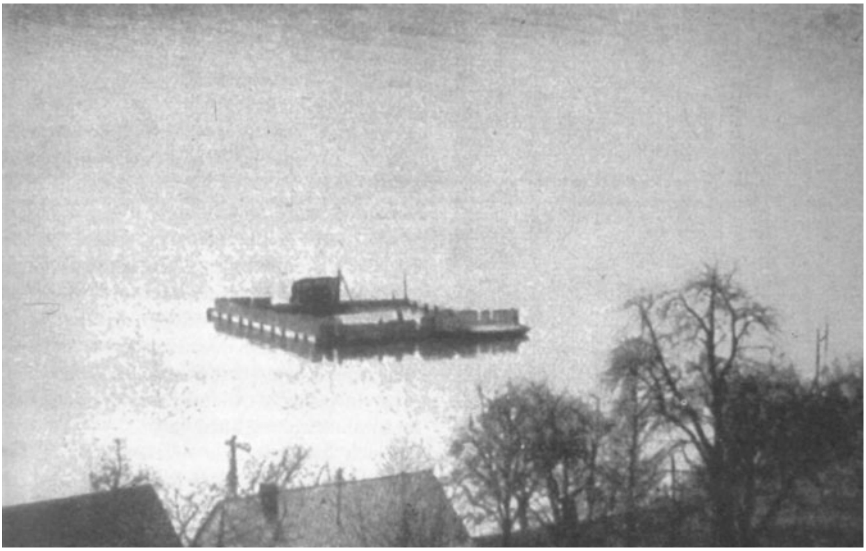


Fig. 5.11. The cofferdam used by Reinerth at Sipplingen, Lake Constance, Germany, in 1929. (*Photograph*: courtesy of Gunter Schöbel, Pfahlbaumuseum, Unteruhlidingen, Germany)

22 × 22 metre double-walled cofferdam (Fig. 5.11), which allowed him to survey more than 400 square metres of the Neolithic lake settlement (Reinerth, 1932).

Since then, the technique has been largely applied in various inundated archaeological sites all over the world (Hafner, 2004; Hafner and Wolf, 1997; Harwath, 1995; Ramseyer, 1988; Schlichtherle, 1997*b*; Zwahlen, 2003). The size of cofferdams varies considerably, from a few square metres, as those used at Wangen, Hornstaad-Hörnle, and Auvernier La Saunerie (Dieckmann et al., 1997; Schlichtherle and Wahlster, 1986), to the impressive ones of Awazu on Lake Biwa, Japan, where the largest of the two measures approximately 120 × 60 metres (over 7000 square metres) (Iba, 2005). Cofferdams are usually used in no more than 3 metres of water, but in some cases, even coastal wrecks as deep as 4 metres (see La Belle wreck, Texas, United States) can be isolated from the surrounding water and excavated with this technique (Bruseth et al., 2005). In exceptional cases as with the Medieval Nanhai 1 wreck, the entire ship can be lifted in a cofferdam and excavated later in a different place (Jiao, 2010). For small projects, portable rented or leased cofferdams with water-control system incorporated are available (Purdy, 2001). Finally, cofferdams can also be used to target specific problems within restricted (and not necessarily flooded) areas without affecting the surroundings. A good example is the excavation at Harinxveld-Giessendam (the Netherlands), where an area of 30 × 18.5 metres was isolated using a special cofferdam made watertight by the injection of

waterglass (a solution of silica, sodium, and water), so that the dewatering process could be limited to the caisson area, thus preventing a fall in the water-table in the surrounding areas (Louwe Kooijmans, 2001*a*, *b*).

Hydraulic Excavation Technique

The hydraulic technique is mostly used on water-saturated coastal as well as river-bank archaeological sites of North America's Northwest Coast. The particular composition of vegetal mat deposits provides an aquifer for the movement of groundwater through the river-bank deposits, which has not only facilitated the preservation of organic materials but also allowed the application of this particular excavation technique. The technique uses pressurized water to remove the deposit (matrix) in which archaeological remains are buried. The particular aquifer property of the deposits allows the water to run off quickly without flooding the area. The equipment used for this type of excavation consists of a pump, which takes water from an adjacent source (river, sea, lake, etc.) and channels it to a hose-tree linked to a number of garden hoses (one for each excavator, depending on the capacity of the pump) (Fig. 5.12).

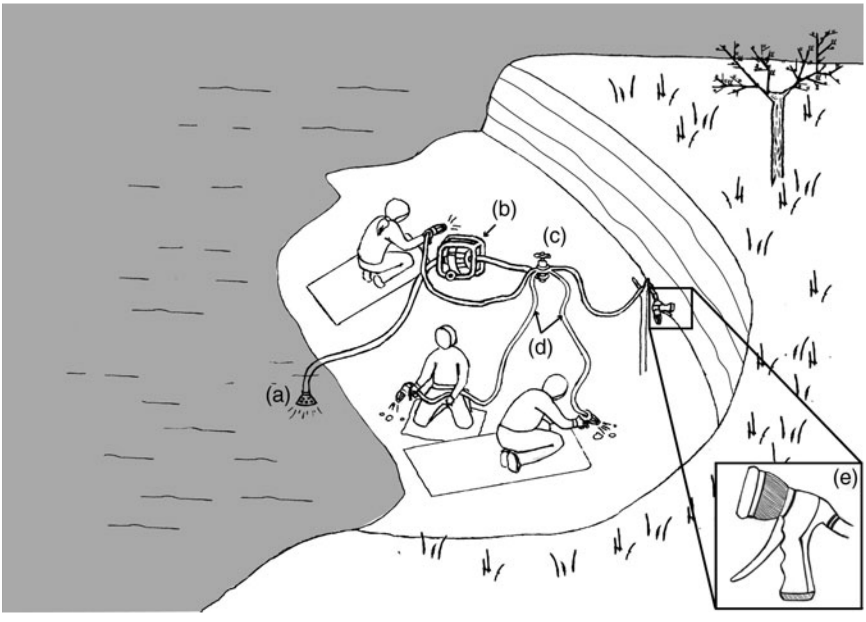


Fig. 5.12. Schematic representation of the hydraulic excavation technique: a) water intake box; b) pump; c) hose-tree; d) garden hoses; e) adjustable nozzle. (*Drawing*: Olenka Dmytryk)

Each garden hose ends with an adjustable nozzle that regulates the water pressure and the intensity of the spray, hence allowing the excavation of large portions as well as fine matrices within which delicate artefacts are trapped. The technique was first applied at Ozette and Hoko River sites (Croes, 1976, 1995; Gleeson and Grosso, 1976), and it has been used ever since in all major wetland excavations of the North America's Northwest Coast.

The Blocklift Excavation Method

The technique, which consists of dividing the excavated area into small blocks, removing them from their original location and excavating them elsewhere later, is mainly used in estuary excavations linked to tidal fluctuations. Archaeological sites situated in a tidal frame are extremely difficult to excavate, for the time between low and high tide is sometimes very limited (in some cases only a few hours). As a result, it is more convenient to remove systematically divided blocks of sediments and micro-excavate them subsequently in another place (e.g. in an excavation camp or a laboratory) without time pressure. The technique has been used successfully for over 25 years, and two of the best examples are the Mesolithic midden of Westward Ho! (Balaam et al., 1987), and the more recent excavation of Goldcliff East (Severn Estuary) (Bell, 2007). The method is fairly effective although very demanding and time-consuming, therefore not particularly suitable for large excavations with extensive wooden structures within the sediments.

Underwater Excavation

This section does not purposely include marine underwater excavations on coastal wrecks, but focuses instead on shallow water lacustrine settlements. Although the first attempt to explore the shallow water morainic shoals of lakes (where ancient lakeside dwellings once stood) dates back to the mid-nineteenth century (see Fig. 5.13), it was not until the 1970s that systematic underwater excavations began.

Excavations of some of the most famous sites such as Charavives-Colletière on Lake Paladru, France (Colardelle and Verdel, 1993), a number of sites on Lake Zurich and Lake Constance (Köninger, 1995*a*, *b*; Ruoff, 1981, 1990, 2004, 2006; Schöbel, 1995), Auvernier-Nord, on Lake Neuchâtel (Arnold, 1983, 1999; Arnold et al., 2004), and more recently the numerous sites on Lake Biel (Hafner, 1992, 1996, 2001, 2004; Hafner and Suter, 2000, 2004; Hafner and Wolf, 1997), have all contributed to perfect the various excavation techniques that are nowadays used all over the world.

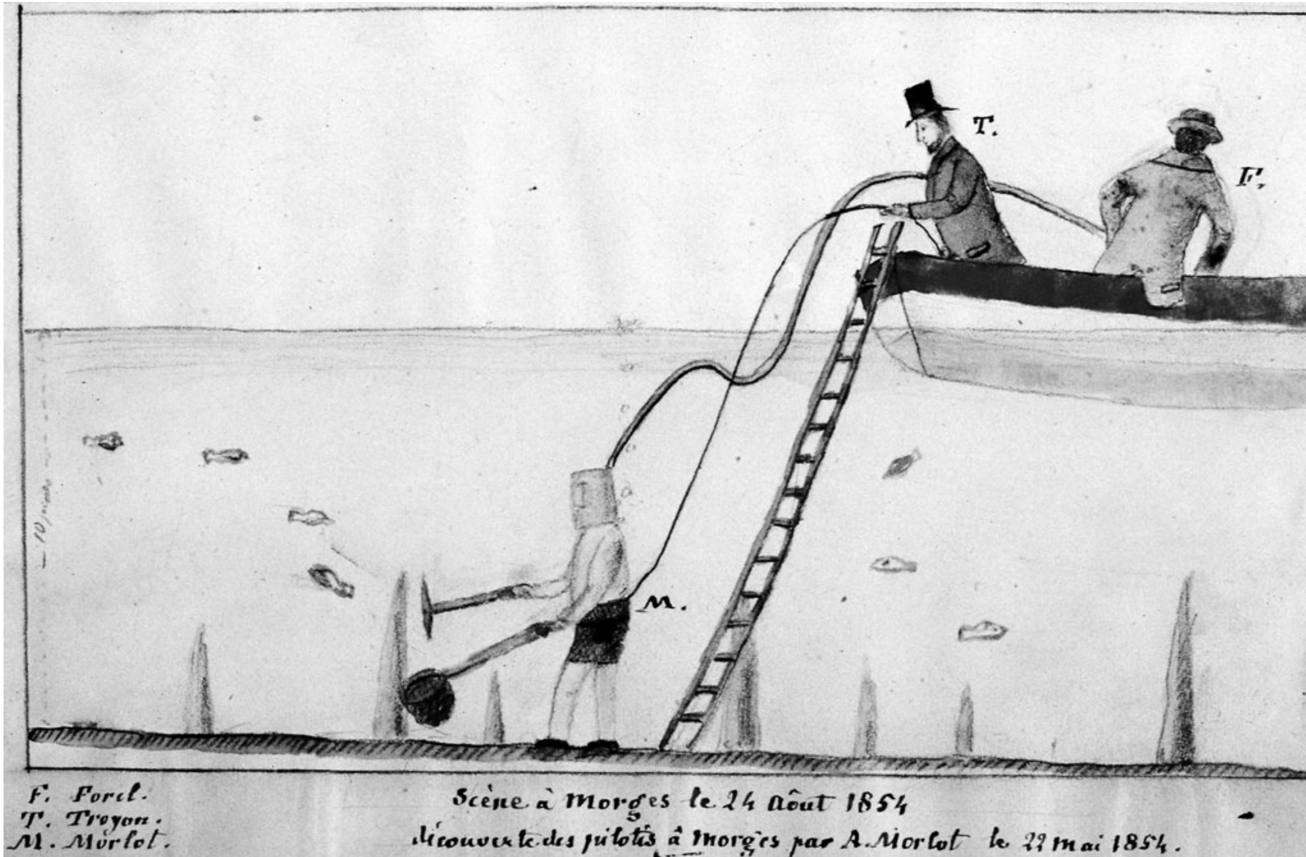


Fig. 5.13. Painting of what is regarded to be the first underwater ‘excavation’ of a Circum-Alpine region lake-dwelling, carried out by Alphonse Morlot at Morges on Lake Geneva, Switzerland, in 1854. (Courtesy of the Bernisches Historisches Museum, Berne, Switzerland)

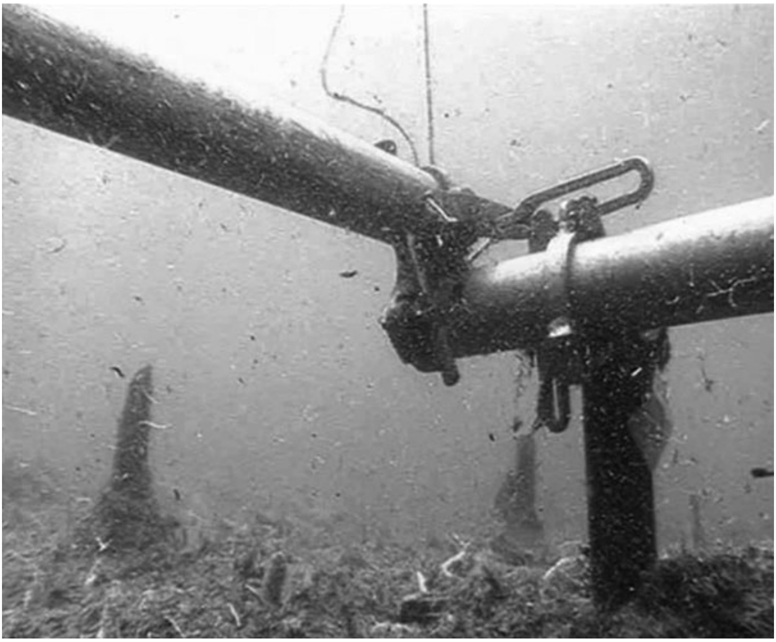


Fig. 5.14. A quick-release fitting holding two scaffolding pipes used for permanent underwater reference grids. (*Photograph*: F. Menotti)

As is the case for other on-land wetland excavations, underwater ones vary significantly from site to site depending on the geomorphology and hydrology of the excavated area. For example, soft lacustrine deposits of small morainic lakes cannot be excavated with the same techniques used for more compact lake marl sediments found in larger glacial lakes. There are, however, standard procedures that are used in all circumstances; setting up a permanent grid over the area to be excavated is one of the most important ones. The grid is usually made of a series of metal pipes like those used in scaffolding. The use of quick-release fittings (Fig. 5.14) makes them much easier to assemble and disassemble underwater.

A boat, raft, or better, a semi-permanent diving platform, should be anchored near the excavated area, which must be signalled by a series of buoys or diving flags in order to be noticed by passing watercraft. The divers' personal equipment and diving suits vary according to the water temperature and depth. Because of better visibility, most excavations in Europe's Circum-Alpine region lakes are carried out in winter, so drysuits are preferred. For summer excavations and/or projects in warmer climates, wetsuits are normally used. Divers can either carry a personal air tank or be linked to a land-based air supply system via long tubes, which can reach several hundreds of metres and provide unlimited amounts of air. For long dives full facial masks are

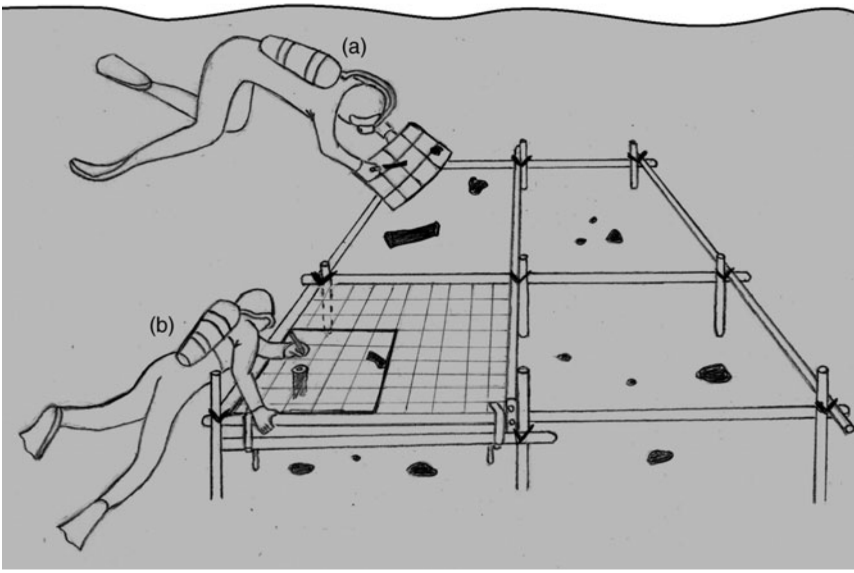


Fig. 5.15. Schematic representation of two different underwater excavation drawing techniques: a) free-hand drawing, using a scaled white board; b) full-scale drawing, using a transparent Plexiglas board. (*Drawing*: Olenka Dmytryk)

preferred, as they are more comfortable and allow radio communication between the divers and the shore base or diving platform.

Recording and measurement techniques in underwater excavation vary significantly from simple manual measuring by means of a tape measure to more sophisticated air hose levels or even laser beams. If the site is fairly close to the shore and not in too deep water the various finds can be recorded with a theodolite (or total station), which calculates the geographical coordinates automatically. The data can then be downloaded directly onto a computer and plotted in 3D. Drawing objects underwater is not an easy task; it can either be done freehand on a whiteboard properly scaled according to the excavation grid (Fig. 5.15a), or, for large areas, a comfortable metal grid is used as a base to support metre-square transparent Plexiglas boards (Fig. 5.15b) (Hafner and Suter, 2004). The same technique is also used to draw vertical clean stratigraphic profiles. In some cases, smaller (e.g. 25 × 25 cm) boards are preferred, being easier to handle and more adaptable to the excavated area (Kinsky, 1995).

Underwater digital photography is becoming more widely used, although visibility (even in the clearest waters) still remains a major issue. Finally, small object retrieval can be difficult under water. A solution is to prepare a tray of standardized size (e.g. 1 × 1 metre), divide it into sections (e.g. 25 × 25 cm each) (see Fig. 5.16f), label them according to the permanent grid, and place the artefacts in the various sections as they are found *in situ* (a lid can also be

placed on top of the tray to prevent light artefacts from floating away). Once the layer (whose thickness is decided by the excavator) is fully excavated, the tray is lifted out of the water, and artefacts plotted on the final drawing.

Vacuum Excavation Method

The vacuum technique is one of the two main excavation methods used in shallow freshwater areas. The technique can be applied in two ways: by suction water pump, or by an airlift produced by pressurized air. The principle of the airlift is fairly simple: using a compressor (see Fig. 5.16b), air is channelled through a hose that reaches the main suction pipe (held by the diver) and is then forced to return upwards. This creates a suction that vacuums up the soft sediments excavated by the diver. The intensity of the suction depends on the capacity of the compressor and the length of the hose. A control valve or tap near the vacuum pipe allows the diver to regulate the suction (see Fig. 5.16g). The airlift method has a few advantages over the water-driven one. For instance, it works slightly better in deeper water (Ekberg, 2003), and the air-supply hose is less cumbersome. However, as pointed out above, it is the capacity of the compressor that plays a crucial role. Once the sediments are vacuumed away, they are deposited on the bottom of a plastic or metal container, while the excess water overflows back into the lake (see Fig. 5.16a). The container is usually cleaned at the end of each 1 × 1-metre layer (the thickness is decided by the excavator), and the content sorted and water-sieved again, just in case small artefacts have been missed by the diver.

Water-jet Pipe Excavation Technique

This technique is used to improve visibility while working under water. From a water pump (Fig. 5.16c), water (from an intake point—see Fig. 5.16d) is channelled to a perforated metal pipe, which creates a series of artificial currents that push the murky water of the excavation behind the diver (Fig. 5.16e), thus keeping the water around the excavation area reasonably clear (Hafner, 2004). The intensity of the current can be regulated by a tap placed just before the device. The technique is normally used in lakes with rather compact lake marl sediments. In fact, in shallow-water lakes with particularly soft sediments the technique can be counterproductive as the water streams may cause even more movement of sediment. The technique is particularly useful for cleaning compact stratigraphic profiles, but it can also be used in conjunction with the vacuum method, if the morphology and consistency of the lacustrine deposit allow it.

The vast diversity of wetland environments requires many different excavation techniques that themselves need to be adapted according to the various locations, climate, soil composition, and type of archaeological remains. Even within the various methods, there is never a fully standardized way of carrying

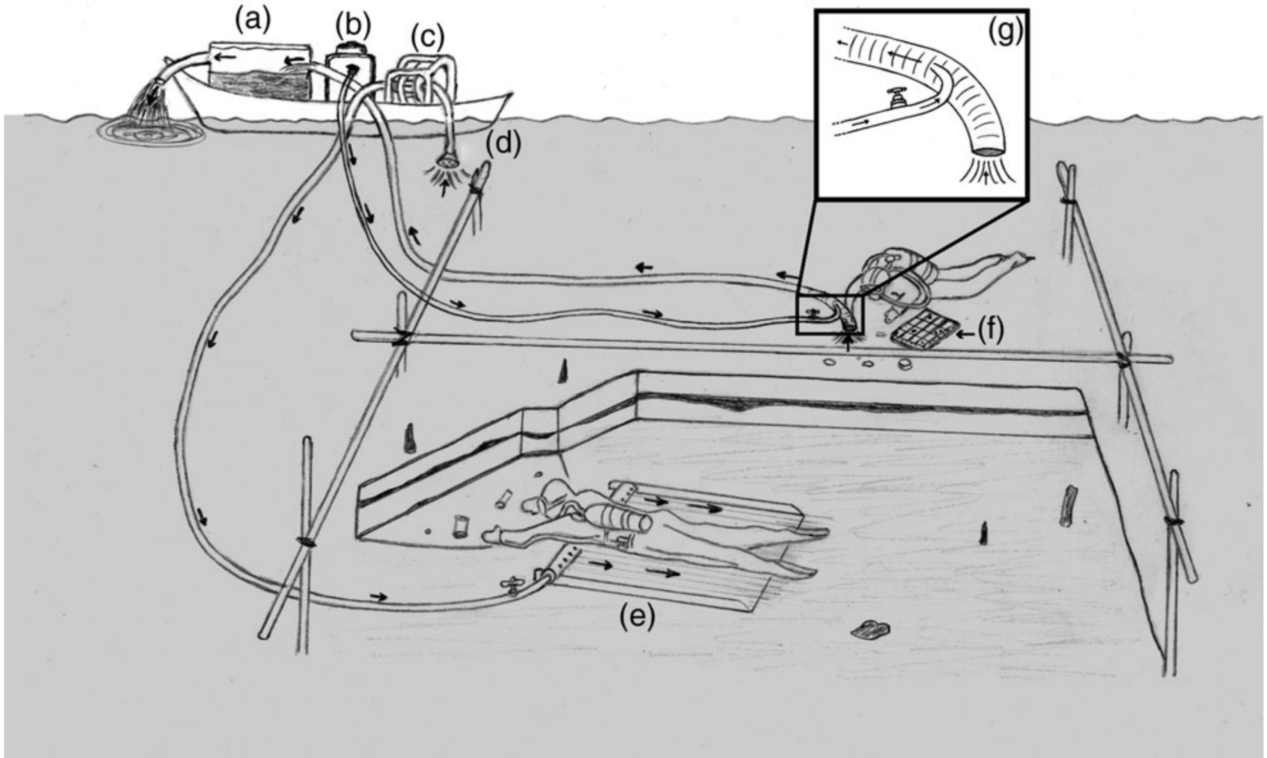


Fig. 5.16. Schematic representation of the vacuum method (diver on the upper right hand side) and the 'water-jet pipe' technique used in underwater excavations: a) plastic or metal container to collect the vacuumed sediments; b) air compressor for the vacuum airlift technique; c) Water pump for the water-jet pipe technique; d) intake box for water pump; e) the water-jet pipe technique (note that the technique only works with pressurized water); f) tray divided in different compartments for small artefact collection; g) the vacuum method with enlarged details. (*Drawing*: Olenka Dmytryk)

out an excavation. Given the main principles, it is always the ingenuity of the individual excavator that is crucial for obtaining positive final results. After all, it is not until the artefacts are exposed to light that the excavator knows exactly what he or she is dealing with. Therefore, only then will it become fully clear what prevents particular archaeological remains from disappearing completely, and most importantly if there is anything that can be done to help maintain or even improve the status quo.

PRESERVATION

Regardless of the various deposition and site formation processes, different wetland ecosystems have different preservation properties, which go beyond sheer water-saturation. Soil chemical composition, pH, and redox potential play a crucial role in the survival of the artefacts after deposition. However, the greatest threat, once again, is human agency. The rate of disappearance of wetland areas in the past one hundred years or so has been alarming. What is even more disturbing is that with the natural environment vanishes our cultural heritage. Environmental organizations as well as scholars from various disciplines have been urging action against this careless negligence towards wetland ecosystems for quite some time. As a result, some countries have reacted positively, starting extensive preservation and protection programmes to maintain and/or regenerate these delicate ecosystems (see below and also Ch. 9).

Natural Preservation

It is often taken for granted that water saturation and anaerobic (anoxic) conditions are enough for archaeological material to be naturally preserved. While this is partly true, the ability of wetland environments to preserve organic material is mainly the result of a combination of factors, which include the wetlands' physical, chemical, and microbiological composition. Waterlogged terrains indeed have the advantage of suppressing microbiological activity, which would otherwise cause decomposition of organic elements. However, it is the wetlands' underlying geology that plays a crucial role in maintaining a chemical balance that facilitates preservation. Two factors seem to be particularly important for sustaining this balance: pH and redox potential (Caple and Dungworth, 1997) (see below). Still, not all material contained in a waterlogged context is the same, and since complex external interactions can influence buried material in different ways, the final outcome (whether or not the material is preserved, and its level of preservation) may not be as expected, even in ideal anaerobic conditions (Lillie et al., 2007; R. J. Smith, 2005). The ideal situation of permanently wet conditions does not happen very often, for the water content of the majority of

wetlands is subject to seasonal fluctuations. These fluctuations are caused by the instability of the water balance; in order for that to be maintained, the sum of all water inputs (groundwater, precipitation, and surface water) to the wetland area should be equal to, or greater than, the sum of the outputs (groundwater, surface water, run-off, and evapotranspiration): $P + I = D + E + (R–C)$ mm, where P = precipitation; I = intrusive water inflow; D = discharge; E = evapotranspiration; R = reserve; C = consumption; and $(R–C)$ = storage (Eggelsmann et al., 1993). It is important to stress that despite the fact that this imbalance can be triggered by natural phenomena, anthropogenic ones (land reclamation, water abstraction, drainage, mineral extraction, etc.) are mostly to be blamed. Short-term reductions may be allowed, providing that the soil has sufficient water-retentive characteristics, but long-term ones may cause serious problems.

The capacity of the soil to allow the passage of water through it (on which water retention in the wetlands depends) is known as 'hydraulic conductivity'. This is defined by Darcy's Law, which can be described in various ways. Eggelsmann et al. (1993), for instance, give the following equation: $Q = k(\delta h/\delta l)$, where Q = discharge across a cross-sectional area; k = hydraulic conductivity; h = hydraulic head; l = length of the flow line; and $(\delta h/\delta l)$ = the hydraulic gradient, whereas Mitsch and Gosselink (2000) describe it as: $G = kA_xs$, where G = the flow rate of groundwater; k = hydraulic conductivity; A_x = the groundwater cross-sectional area perpendicular to the direction of flow; and s = the hydraulic gradient. Both equations show that hydraulic conductivity is basically the product of the cross-section through which water is flowing, the gradient of the flow, and the volume of water that percolates in a certain amount of time. As hydraulic conductivity shows, the capacity of soil to retain water is a valuable way to assess the potential of wet/wetland archaeological sites to preserve artefacts. For instance, a wetland environment with low hydraulic conductivity will retain more water and at the same time limit the influx of oxygen-rich water from other surrounding areas (Van de Noort and Davies, 1993).

As briefly mentioned earlier, the highly complex chemistry of the wetlands depends upon both inorganic elements (deriving from geology) and the organic chemistry of the peat (and other vegetation), as well as their degradation processes. Amongst them, the balance between pH and redox potential plays a crucial role in the final preservation of organic materials. The pH provides the degree of acidity or alkalinity in a given substance, whereas the redox potential (Eh) gives the level of oxidation or reduction in the soil. Reduction occurs when electrons are gained by ions and become negatively charged. Conversely, when electrons are lost, a process of oxidation (positive charge) takes place (Corfield, 1996, 2007). In the event of temporary dewatering of a waterlogged area, soluble minerals are oxidized and organic materials are more prone to degradation. Ideally the redox potential for anaerobic sediments should be low, between *c.*+200 and –400 mV. Values above (e.g. $>$ +300 mV) are not particularly suitable for the preservation of delicate organic material (Corfield, 1996, 1998). An important factor that has

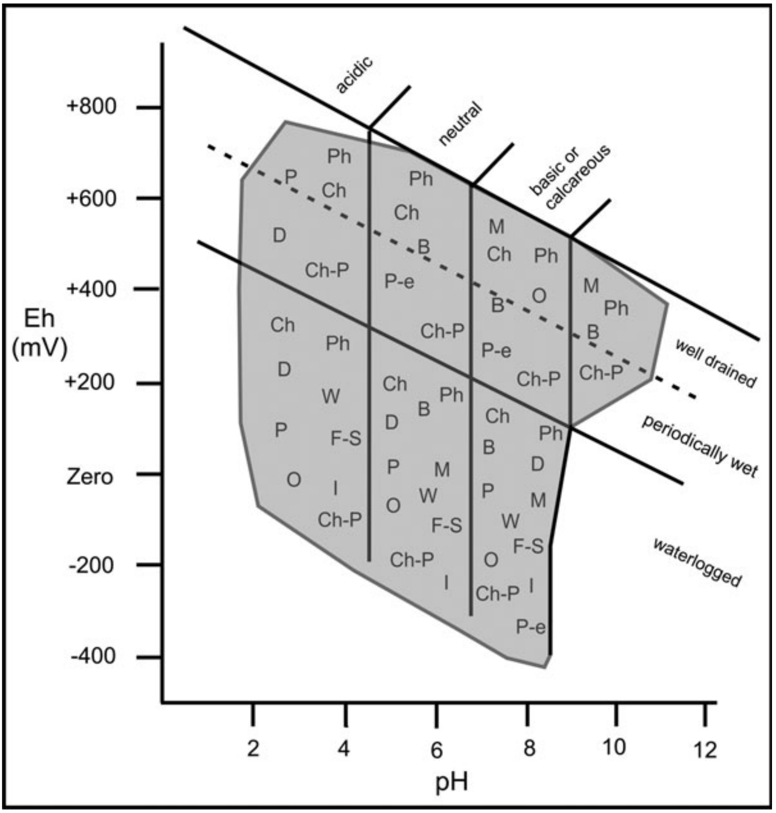


Fig. 5.17. Joint effects of redox potential (Eh) and pH on the preservation of archaeological organic materials. (*Graphic*: A. Hurina. Data source: Retallack, 1984). Key: P-e = Parasite eggs; Ch-P = Charred plants; I = Insects; O = Ostracods; W = Wood; P = Pollen/spores; M = Molluscs; D = Diatoms; F-S = Fruits/Seeds; Ch = Charcoal; Ph = Phytoliths; B = Bones.

to be taken into account is the relationship between pH and redox potential, especially in permanently waterlogged and periodically flooded environments (Caple and Dungworth, 1997; H. Cook, 1999; Retallack, 1984). It is particularly interesting to notice how bones are better preserved in both well-drained and waterlogged neutral to calcareous environments, but not in periodically wet ones, whereas parasite eggs thrive in these latter conditions and not in either well-drained or waterlogged ones (see Fig. 5.17).

Another important factor in the preservation of organic material in the wetlands is the presence of bacteria, which are crucial for a large number of chemical processes in the soil, particularly waterlogged soils. There are two kinds of bacteria: aerobic (require oxygen for their metabolism) and anaerobic (not needing oxygen). The latter type is itself divided into two further categories: (*a*) facultative anaerobes (that grow with or without oxygen) and (*b*) obligate anaerobes (that grow only without). Of the two, it is the facultative anaerobes

Fig. 5.18. The Holme Fen post, Cambridgeshire, England. The top of the post was the level of the ground in 1848—the peat has shrunk more than 3 metres. (After Coles, 1984: 28)

that deplete the wetland oxygen, reducing the redox potential and creating anaerobic conditions ideal for the preservation of organic material. However, while creating anaerobic conditions, it has been shown that they also contribute to the deterioration of some organic material, in particular wood (Freeman et al., 2004; Hoffmann et al., 2002; Sikora and Keeney, 1983).

Managing Preservation on Archaeological Sites

The combination of factors that favour the natural preservation of organic materials can easily be altered, and, as mentioned in the previous section, is influenced by both natural processes (e.g. climate change) and human

activity (drainage, water abstraction, pollution, and mineral and peat extraction). One of the best examples of negative effects that drainage has on wetland environments is the Fenland (England). Here, due to intense drainage in the second half of the nineteenth century, the peat surface shrank more than 3 metres in less than 50 years, as is shown by the famous Holme Fen post (see Fig. 5.18) (Coles, 1984: 28). As a result, archaeological material buried in the wetlands is in serious peril and will disappear if no preventative measures are taken.

Stabilizing Water-tables: Oxidation and Reduction

One of the major concerns in protecting *in situ* waterlogged archaeological remains is to stabilize the water-table in order to maintain water-saturated conditions and prevent degradation. This is achieved by establishing monitoring points within those endangered wetland archaeological sites. There are a number of ways to monitor the physical, chemical, and microbiological compositions of water-saturated environments. The installation of piezometers (or deepwells) (see Fig. 5.19) allows *in situ* monitoring of groundwater variations, the collection of water samples for chemical analysis, and the evaluation of lateral flow paths of the water and nutrients (Brunning, 1999).

A few parameters (pH, oxygen, and conductivity) can be measured directly in the piezometers, by using appropriate electrodes. Others (e.g. sulphate, sulphide, ammonium, nitrate, potassium, phosphate chloride, etc.) are measured by extracting water from the deepwell with a syringe. Redox potential is usually measured by probes or electrodes directly installed in (driven into) the soil. In this way, contamination (which may occur with extracting water from the deep wells) is reduced significantly (Matthiesen, 2004; Matthiesen et al., 2004).

There have been several (some still ongoing) *in situ* environmental monitoring projects on a number of waterlogged archaeological sites all over Europe, in the past two decades. Some of them were quite successful and led to the identification of various shortcomings with monitoring and analytical techniques. For instance, following the installation of a water pump system to maintain a stable water-table within the Shapwick Nature Reserve (Somerset Levels), in the early 1980s, a monitoring project to test the results of such preservation initiatives started in the mid 1990s (Brunning, 1999, 2007*a*, *b*). A series of monitoring points (piezometers and redox potential probes) have confirmed that the pump system succeeded in preventing the development of aerobic conditions around the Sweet Track, although some parts that were not directly benefited by the pump system showed vulnerability to desiccation (Brunning, 1999). Significant monitoring projects have also been carried out in other parts of the United Kingdom, such as at Sutton Common (Humber Wetlands), Flag Fen (Fenland), and on five crannog sites (namely Loch Arthur, Milton Loch, Barlockhard,

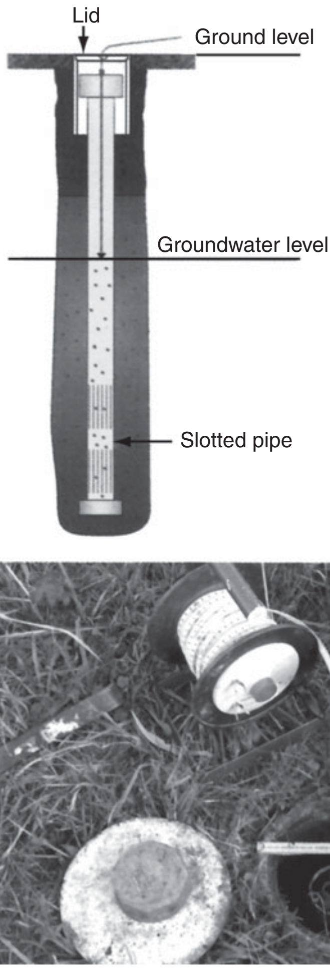


Fig. 5.19. Schematic representation and picture of a piezometer. (Courtesy of Stefan Hochuli, Kantonsarchäologie Zug, Switzerland)

Whitefield Loch, and Cults Loch) in south-west Scotland (Chapman and Cheetham, 2002; Lillie, 2007; Lillie et al., 2007). On Europe's mainland, there was a major environmental monitoring undertaking at the famous Iron Age lakeside fort of Biskupin (Poland), between 2003 and 2006. Redox potential values showed high reductability, which was nevertheless threatened by intermittent low values (especially in the summer) due to the supply of polluted water (communal waste, pesticides, etc.) from the lake, precipitation, and temperature fluctuations. It was therefore decided to reduce uncontrolled pumping of water in the summer months (Babiński et al., 2007). Important programmes of wetland archaeological site monitoring

have also been carried out in the Netherlands; see, for example, Nieuw-Dorecht Moor (Smit, 2004), and the protected site of Spijkenisse-Vriesland (van Heeringen and Theunissen, 2006). A further outstanding environmental monitoring project was also completed at the famous waterlogged site of Nydam in Denmark (Gregory and Jensen, 2006; Matthiesen et al., 2004; Sørensen and Gregory, 1998). The seven-year project has contributed to shedding light on various aspects of monitoring methodology. For instance, purging of the deepwell (piezometer) before sampling may have some advantages if combined with fast sample handling; or, the redox potential shows more stability if measured by permanently buried gold electrodes, which, in some cases, have proved more reliable than the previously preferred titanium ones (Matthiesen et al., 2004). Finally, despite the absence of large peat formations, monitoring projects have even been carried out in the Circum-Alpine region lacustrine areas, with one of the best examples being that of Oberrisch-Aabach and Zug-Sumpf on Lake Zug (Switzerland), where (especially for the former site) it has been established that due to a constant decline of the water-table, the future preservation of the still-buried archaeological materials would only be possible by a constant rewatering of the area (Hochuli and Schaeren, 2006).

Constant human agency, along with natural environmental change (e.g. climate change), has increased the process of desiccation, even in the most humid areas. As a result, *in situ* monitoring preservation of waterlogged archaeological material has become a crucial and essential part of Cultural Heritage management. Maintaining the sites wetness is not the only problem; destruction of archaeological evidence is also caused by erosion, which in some lacustrine and coastal areas has become more severe in recent years.

Anti-erosion Measures

In the early 1980s, archaeologists working on ancient lake-shore settlements and coastal occupations were, for the first time, faced with a threat that had not hitherto been particularly noticed: erosion. The cause of the increase in erosion is twofold: (*a*) a marked change in climatic conditions, and (*b*) an increase in human activity around the lakes. Together these causes have disturbed the hydrological balance of small and large bodies of water and created an exaggerated effect of erosion that has been destroying natural and cultural heritage in and around lacustrine areas. Particularly affected by this phenomenon is the Circum-Alpine region and surroundings, where a large number of lake-shore archaeological sites have already been lost to erosion in the past thirty years. On Lake Geneva for instance, a survey carried out between 1981 and 1985 showed that only a dozen settlements (out of over sixty) still retained anthropogenic layers in place (Ramseyer and Roulière-Lambert, 1996, 2006). It was realized that the situation was critical and action had to be taken immediately. A consensus was established between

Fig. 5.20. Anti-erosion wooden fences near Risch on Lake Zug, to protect lakeshore anthropogenic layers against wave action. (Courtesy of Stefan Hochuli, Kantonsarchäologie Zug, Switzerland)

archaeologists and environmental conservationists, and the first prevention measures to protect natural and cultural heritage were adopted. Lack of familiarity with anti-erosion measures caused more than a few problems and failures, which nevertheless led to a more reliable methodology and more satisfactory results. For instance, the use of wooden fences to protect the site against lake wave action (see Fig. 5.20) was effective in only some areas (Eberschweiler, 2006; Hochuli and Schaeren, 2006).

Similarly, the covering of eroding lake bottoms with large bags of gravel proved to be too heavy for the anthropogenic layers, and finally, reed rhizomes meant to reinforce and protect the lake bottom, penetrated too deep into the sediments, damaging the archaeological wooden structures. However, this last

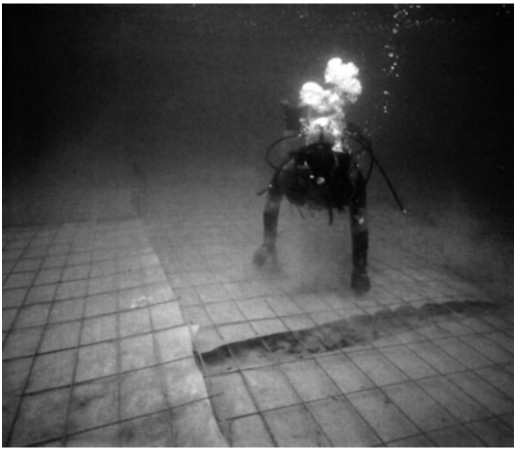


Fig. 5.21. Anti-erosion geo-textiles (reinforced with wire mesh) placed on the anthropogenic layers of Bodman-Schachen 1, Lake Constance, Germany. (*Photograph*: courtesy of Joachim Köninger)

method proved to be quite effective in some areas. In fact, in Greg (Lake Morat, Switzerland), and on the western shore of Lake Chalain (France) processes of revegetation along the lake shores were quite successful, and both areas are now fully protected (Pétrequin, 2001, 2006; Ramseyer, 2006). In the mid-1980s, German archaeologists started to use a new technique, consisting of geo-textiles reinforced with wire-mesh deposited on the shallow-water anthropogenic layers (see Fig. 5.21), and covered with pebbles and gravel.

The method has been applied on a number of submerged lacustrine settlements on Lake Constance (e.g. Bodman-Schachen 1, Nussdorf-Strandbad, Hornstaad-Hörle I and II, Wangen-Hinterhorn in Germany, and Ermatingen in Switzerland) (Brem, 2006; Köninger and Schlichtherle, 2006). More recently, the technique has also been applied on Lake Biel (e.g. Sutz-Lattrigen-Hauptstation), where it has even been improved by substituting the metal wire-mesh with a highly resistant thick geo-textile mat filled with cement-like sediments, which too was eventually covered with pebbles and gravel as usual. Both operations (geo-textile laying and gravel covering) were performed with a specially constructed flat-bottomed boat (see Fig. 5.22) (Hafner, 2005, 2006; Hafner et al., 2006).

Anti-erosion measures are not only adopted around the Circum-Alpine region lakes, but also on maritime coastal areas. One of the best examples is the groyne system (two groynes) built on the beach to protect the Medieval sunken village of Valkenisse in the Netherlands (van Heeringen and Theunissen, 2006, 2007).

Whether used to stabilize the water-table preventing desiccation, or against erosion, protective measures to safeguard our cultural heritage are

Fig. 5.22. Specially constructed flat-bottomed boat used to lay the protective anti-erosion geo-textile and gravel at Sutz-Lattrigen-Hauptstation, Lake Biel, Switzerland. (*Photograph*: courtesy of Albert Hafner, Archäologischer Dienst des Kantons Bern, Switzerland)

sometimes not enough and more 'destructive' activity (salvage excavation) is required. In this case, organic artefacts (e.g. wood) recovered may be badly damaged and in need of particular attention. Conservation is therefore as important as prevention, once the archaeological remains can no longer be protected naturally.

CONSERVATION

Waterlogged organic artefacts (especially wooden objects, basketry, and textiles) are extremely delicate; once they are taken from their natural water-saturated context, they warp and become damaged very quickly. It is therefore important that they undergo a prompt and systematic process of conservation, starting *in situ* (when the objects are first brought to light in an excavation), and continuing in the laboratory, until the process is completed and the artefacts are no longer in danger of decay. This section discusses the various procedures of conservation, from temporary measures of protection (e.g. water-tank immersion, cling-film wrapping, etc.), to final and permanent

conservation (e.g. PEG treatment, freeze-drying, air-drying, etc.) for further studies and/or display.

Conserving an archaeological object has not only scientific and aesthetic (for display) value, but also cultural significance (Clavir, 2002; Slogget, 2009). An object is a representation, and, through time, a perpetuation of cultural traits. Hence its indefinite conservation has to agree with cultural views and values of specific cultural aspects of people (e.g. ethnic groups) linked to the object. In some cases the connections between the present and the ancient artefact are lost, but in some other cases they can still be traced. These connections are vital when the future of an ancient artefact (whose creators' descendants are still alive) is decided.

Waterlogged Archaeological Wood

Although in wetland archaeological excavations a variety of objects made of different organic materials need conservation, wood is by far the most commonly treated one. Before embarking on a conservation process, a number of variables have to be taken into account, such as wood species, level of degradation, method to be applied (in relation to the purpose of conserving the object, and the various pros and cons of the methods), the pre- and post-treatments, and the assessment of the final results (Grattan et al., 2006).

In waterlogged conditions, ancient wood consists of a lignin framework filled with water. If the water evaporates (e.g. when the object is in aerobic conditions), the delicate cell walls collapse, causing the object to warp or to distort (see Fig. 5.23). Due to natural as well as anthropogenic causes, this degrading process may start even before the objects are extracted or excavated from their matrix (Brunning, 2007*a*; Gregory and Jensen, 2006) (see previous

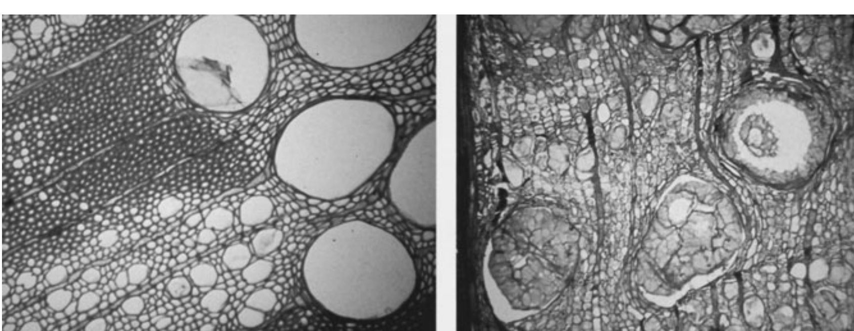


Fig. 5.23. SEM photographs showing the intact structure of fresh oak (left) and degraded and distorted cell structures of the Sweet Track oak (right). (*Photographs*: © Per Hoffmann, Deutsches Schiffahrtsmuseum Bremerhaven, Germany)

section). However, once the wood is taken out of the waterlogged context, the only way to conserve it is to replace the water in the cell lumen and areas of the cell walls with a consolidant (e.g. PEG, sugar solutions, etc.) (Hoffmann, 1985, 2009; Hoffmann et al., 2004*b*). Unfortunately, in most cases conservation processes do not start immediately after the wood is extracted from the natural waterlogged context. In fact, the period elapsing between the excavation and conservation can be exceedingly long, and, if no preventative measures are taken the wood may be severely and irreparably damaged. Although only a temporary solution, the best way to keep the wood waterlogged is to wrap the artefacts in cling-film or sealed plastic bags, or, even better, to store them in water containers. In substantial excavations with a large quantity of wood (possibly of some size), temporary storage may be a problem. A solution is to construct sizeable water tanks, possibly fitted with an ultra-violet water circulation system (acting as a biocide) to prevent fungal infection. Temporary water tanks can easily be constructed using simple wooden frames lined with polythene sheeting. Such water tanks were used at Flag Fen (England) to keep the large quantity of wooden materials wet prior to analysis and conservation (Pryor and Taylor, 1992: 42). Once the wood has reached the conservation laboratory the various treatments can begin.

In order to choose the most suitable method of conservation a number of pre-treatment assessments should be performed. It is, for instance, important to calculate the triangular, radial, longitudinal, and volumetric shrinkage, identify the species of wood to be treated (not all species react the same way), and if possible, calculate the percentage of cell matter lost during deterioration. The objects should also be photographed before the conservation process. In order to eliminate (or significantly reduce) reflection or scattering of light from the wet surface, small objects can be photographed under water in small water containers, if a suitable window attachment can be fitted to the camera (Grattan et al., 2006).

Wood and Polyethylene Glycol (PEG) Treatment

Polyethylene glycols (PEGs) are synthetic polymers of ethylene oxide perfectly miscible with water and able to penetrate the cell walls and support the lignin framework, once the water is extracted by controlled air-drying or freeze-drying (see below). PEG is available in a range of different molecular weights (MW), from 200 MW to 3,350 MW (also known as PEG 4000). In the early 1980s, wooden objects were initially impregnated with PEG solution only once (Cook and Grattan, 1985; Grattan, 1982). Subsequent research led to the discovery that low molecular weight PEG (200–400) was more suitable for less degraded wood, whereas high molecular weight PEG (3350) added extra strength to the heavily degraded one (Young and Wainwright, 1982). It was

based on this discovery that Hoffmann (1986, 1988, 1990), working on the Bremen Cog, developed the two-step impregnation technique whereby artefacts are initially immerse in a low MW (e.g. 400) PEG solution, then washed and retreated with high MW (e.g. 3350) PEG. In both impregnations (low and high MW), the percentage of PEG in water is gradually increased (e.g. from 5% to 40%) during a specified amount of time, depending upon the size of the artefacts, the wood species, and the level of degradation (Cook and Grattan, 1991; Grattan et al., 2006; Johns, 1998).

Despite the flexibility and good results, the PEG treatment does have a few shortcomings. It is prone to oxidative degradation, which may result from high temperatures (though sometimes occurring even at low temperatures), large surface areas, and the catalytic effect of heavy ions. Hence, strong light, elevated temperatures, and the addition of salt to the solution should be avoided (or at least limited) (Bilz et al., 1994; Crawshaw, 2009). Another major problem is the formation of acetic acid in PEG-treated wood coming from marine environments (e.g. salty waters). Whitish/yellow degraded patches have been noticed in PEG-conserved wooden ships, such as the *Vasa* (Sweden) (Glastrup et al., 2006, Mortensen et al., 2007), the *Mary Rose* (United Kingdom), and the *Batavia* (western Australia) (Fors et al., 2009; Wetherall et al., 2008). Recent studies have also shown that not only sulphur but also iron could be a cause of oxidative degradation (Almkvist and Persson, 2009). It is therefore important to minimize the formation of acid by trying to remove the residue of iron and sulphur prior to the PEG treatment (Giorgi et al., 2006; Sandström et al., 2003). Reducing oxygen content, lowering temperature, and stabilizing humidity (ideally to below 55%) are considered to be positive preventative measures to reduce acid production. Notwithstanding these limited shortcomings, PEG treatment is considered to be the best treatment to conserve wood, and it has a number of advantages. It is biodegradable, requires a non-toxic solvent (only water), is fairly inexpensive, has predictable results, (to a certain

Table 5.1 Different treatments and results for waterlogged wood (Data provided by Dilys Johns, University of Auckland, New Zealand)

	PEG	SUGAR	SUPERCRITICAL DRYING	ACETONE ROSIN
Treatment	Slow	Slow	Fast	Slow-moderate
Biodegradable	Yes	Yes	Yes	No
Solvent	Water	Water	Methanol/ethanol	Acetone
Cost	Economical	Economical	Expensive	Moderate
Expertise	Yes	Yes	Yes	Yes
Predictable results	Yes	Sometimes	Sometimes	Sometimes
Reversibility	Yes	Yes	Yes	No/limited

extent) very large objects can be treated (either by spraying or full immersion—see the *Vasa*), the procedure is reversible (e.g. the solution can be extracted from the treated wood and repeated, if required), and, finally, the appearance of the conserved artefacts remains fairly natural (although objects do become slightly darker) (Grattan et al., 2006; Hoffmann, 1986; Hoffmann et al., 2004*a*; W. C. Smith, 2003) (see also Table 5.1).

Acetone Rosin

Acetone rosin belongs to the category of irreversible treatments. The solution is not biodegradable, is highly toxic, has a rather slow treatment process (months to a year), has poor long-term stability, and requires fireproof tanks and explosion-proof ovens (which may cause some restriction to the size of the objects). The technique is, however, not very expensive, the wooden artefacts maintain a natural colour, and it can be good for composite artefacts (Mckerrell et al., 1972) (see also Table 5.1).

Sucrose Solution

The sucrose solution is another inexpensive conservation method used instead of PEG. Although results can be quite positive, the technique presents a number of problems, such as the susceptibility of sucrose to yeast fermentation during the treatment. This can, of course, be avoided (or reduced) by sterilization of all equipment, implying an exaggerated rise of costs (Hoffmann, 1998). Wood treated with this method has a relatively slow response to humidity changes and a good long-term stability, but the objects may attract insects during storage and display. The method requires only water, not toxic solvents, and is reversible (see also Table 5.1). Good results in wood conservation can also be obtained with other methods that utilize sugars such as lactitol (Imazu and Morgos, 2002) and in particular sorbitol, with its reasonably good anti-shrinkage properties (Jones et al., 2009).

Pre-treated Wood-drying Techniques

Freeze-drying and Controlled Air-drying

Two methods are usually used to dry pre-treated (e.g. PEG) waterlogged wood: Freeze-drying and controlled air-drying. Freeze-drying is normally preferred for largely degraded wood. The technique reduces the cell surface tension forces of the liquid drying in the treated object, making the drying process more uniform.

A limitation, however, is that large objects require a large freeze-drier, which might not be available. In this case the controlled air-drying method could be a solution. The technique simply requires a humidity chamber, which can easily be created with polythene sheeting, and special equipment to regulate the relative humidity (RH) inside the chamber gradually, until the wood has reached the desired level of moisture (*c*.50–55% RH) (May and Jones, 2006). The results are as good as, and sometimes better than, those of the freeze-drying technique, with the advantage of allowing continuous monitoring of the process, which, if required, can be stopped to allow further impregnation.

Supercritical Drying

The technique is particularly suitable for drying low-strength materials. Water in the wooden sample is replaced with methanol, which is subsequently substituted with supercritical carbon dioxide at high pressure. The sample (object) is finally decompressed and ready to study or display (Kaye and Cole-Hamilton, 1998). Results are quite satisfactory: fast treatment, a natural appearance of the artefacts at the end of the process, acceptable shrinkage values, biodegradability, and reversibility. However, the technique is fairly expensive, the gas used is flammable and toxic, and, because of the limited size of the autoclave chamber, large objects cannot be treated (Kaye et al., 2000; Schindelholz et al., 2009).

Assessing the Results: The Anti-shrink Efficiency (ASE)

The best way to assess the effectiveness of the various treatments is to measure the anti-shrink efficiency. ASE values compare the shrinkage (in radial or tangential directions) of cell collapse produced after the treatment, with the ASE occurring on non-controlled air-drying. Grattan et al. (2006: 54) show, for instance, that samples with no PEG treatment produce very bad results, as opposed to an almost shrinkage-free sample if treated with 25 per cent PEG 400 and then freeze-dried. PEG 4000 (3350) dissolved in tertiary butanol, and the two-step PEG 400–4000 used by Hoffmann for the Bremen Cog conservation have also produced excellent results (Hoffmann, 2001).

Waterlogged Organic Materials Other than Wood

Despite the large quantity of fibre-work, textiles, and basketry found in waterlogged conditions, systematic research on conservation of this type of material is fairly limited, especially on physical and chemical properties of water-saturated cellulosic fibres and the various methods of treating them.

Ethulose, glycerol mixtures, and PEG (low MW) have all been used with satisfactory results, with the latter, however, resulting in poor cohesion and damp surfaces (Peacock and Schofield, 1997). Instead, silicon oils have produced excellent results on cordage and basketry (W. C. Smith, 2003).

Waterlogged leather also suffers irreversible damage if dried without pretreatment (Kite and Thomson, 2007). Low MW PEG with freeze-drying seems to be one of the most successful and most applied methods concerning leather conservation. Finally, if the water is calcareous, waterlogged conditions preserve bones quite well. However, once extracted from the humid context, they too need conservation. Contrary to what was previously thought, polyvinyl acetate (PVA) or Acryloid B-72, normally used with dry bones, is not suitable for wet or damp items. On the other hand, the acrylic emulsion Rhoplex-AC33 has been successfully applied to wet bone artefacts, and can be used in the field as well as in the laboratory. In some cases, the Rhoplex-AC33 has also been used with delicate items such as matting, plant specimens, and fabric (Stone et al., 1990). However, Rhoplex-AC33 does cross-link with some bio-molecules and it may cause problems with further analysis. It is therefore suggested that it should be avoided if the sample is to be dated and/or used for other bio-molecular analyses.

CONCLUSION

Field techniques (survey and excavation), preservation, and post-excavation conservation of material culture retrieved from waterlogged environments are some of the very few aspects of wetland archaeology that should be separated from conventional (dryland) archaeology. The difficulty of surveying and detecting archaeological evidence buried in water-saturated (including underwater) areas has encouraged archaeologists to adapt old and develop new surveying techniques, ranging from aerial photography to more sophisticated satellite imagery, thermography, and differential Global Positioning System (dGPS); and, underwater, from single beam echo sounders (SBES) to sub-bottom profilers (SBP), which are able to penetrate sea or lake beds and identify possible archaeological materials buried in them. The variety of survey methods discussed in this chapter shows the willingness of archaeologists not to leave to chance the discovery of archaeological material in the wetlands. Non-invasive survey techniques have been the main focus of archaeologists' research perspectives, which also mirror those of the environmentalists. These common views have triggered a synergetic collaboration, more conducive to the protection than destruction of our natural as well as cultural heritage (see also Ch. 9).

Where prevention and protection are no longer options, then excavation is the ultimate resort. Not only do wetland archaeology excavations differ from

those of dryland sites, but they also differ within the various waterlogged environments according to their location, geomorphology, and hydrology. It has been seen, for instance, that the hydraulic excavation technique is used almost exclusively on the Northwest Coast of North America; and that dewatering systems (wellpoints) are not often used in European peat excavations, while the similarity of tools adopted (trowels, wooden spatulas, and bare fingers) is internationally widespread. Similarly, the various underwater excavation methods are not applicable everywhere, but limited to the geomorphologic composition of the underwater sediments. For example, while the vacuum technique can be applied to both soft and more compact types of lacustrine marl, the water-jet technique is only suited for the latter type of sediment, because very light particles (e.g. those found in shallow morainic lakes) would reduce, rather than improve, visibility.

Another important topic covered by this chapter is preservation, which can be divided into two parts: (*a*) the natural preservation of organic artefacts in relation to the soil geochemical composition as well as the hydrology of the waterlogged terrains, and (*b*) the natural and anthropogenic influence on those delicate ecosystems that maintain/disrupt the required balance for a successful long-term preservation of organic archaeological materials. Understanding the chemical composition of water and soil facilitates the development of preventative measures, which range from maintaining water saturation in high water-table environments (peatbogs, fens, etc.), to anti-erosion techniques applied on coastal, lake-shore, and river-bank areas.

Where preservation is no longer an option, and archaeological artefacts have to be taken out of their naturally preserving matrix, conservation methods are important to avoid total destruction. In fact, once delicate organic material (plant remains, wood, leather, textiles, etc.) are no longer waterlogged, an irreversible drying process begins, leading to inexorable and irreversible damage. This can be avoided by a number of conservation methods able to substitute the excess of water (which indeed keeps the artefacts in shape) with various consolidants (e.g. PEG), allowing the objects to retain their natural shape for further studies and/or museum display.

6

Joint Effort: A Multidisciplinary Scientific Network

INTRODUCTION

What is difficult to see is usually more important than what is not in wetland archaeology. Because of the large variety of well-preserved micro- and macro-organic remains (both flora and fauna) that allow the possibility of carrying out a whole host of scientific analyses, wetland archaeology has a distinct multidisciplinary orientation.

Some forty years ago, archaeologists involved in multidisciplinary research boosted the adoption of this innovative research approach to attract the attention of the academic community. As time elapsed, the effectiveness of the approach resulted in this feature being taken for granted within archaeological projects. Today multidisciplinary research in archaeology no longer makes headlines, but has simply become an accepted part of the discipline; and this is even more true within wetland archaeology. The joint collaborative effort of various disciplines has even become a verifying tool to prove (or disprove) the results of each discipline. For instance, as discussed in Box 3.1 (Ch. 3), climatic worsening in the Neolithic Circum-Alpine region was confirmed by dendrochronology as well as archaeobotany, which also identified crop failure that consequently triggered an increase of hunting activity, later also confirmed by archaeozoological studies.

Three subdisciplines of archaeology strictly linked to wetland archaeology are archaeobotany, archaeozoology, and geoarchaeology (including micromorphology). Amongst them, the busiest, in terms of workload, is certainly archaeobotany. The high number of plant remains yielded by waterlogged archaeological sites has allowed archaeobotanists (along with palynologists) to reconstruct palaeoenvironments, palaeoeconomies, and palaeoclimates (Jacomet, 2004, 2007; Jacomet and Brombacher, 2005*b*; Poska et al., 2004). Where minerogenic and calcareous waterlogged deposits allow the preservation of bones and antlers, archaeozoology can be of great help in understanding the relationship of people to animals (hunting and

domestication), their evolution (development of new species and extinction of others), and their economic value within the community. Some foremost achievements of archaeozoology within wetland archaeology have been, for instance, the identification of hunting management on Lake Zurich in the Neolithic (Arbogast et al., 2001; Schibler, 2001*b*, 2004, 2008), or confirmation that the first appearance of cattle in Denmark was much earlier than was previously thought (Noe-Nygaard and Hede, 2006). A currently developing research area linked to both archaeobotany and archaeozoology is ancient DNA studies (Dobney and Larson, 2006; Gilbert et al., 2005; Zeder et al., 2006). The discipline is particularly active within domestication and migration issues, concerning not only animals but also plants (Schlumbaum et al., 2008). The third subdiscipline of archaeology that is fully integrated within wetland archaeological research is geoarchaeology. The discipline, with a special emphasis on macromorphology, has been collaborating very closely with archaeobotany, working on palaeovegetational as well as palaeoclimatic reconstructions linked to hydrological imbalances in the wetlands (Ismail-Meyer and Rentzel, 2004; Lewis, 2007; Magny, 2004*a*). An area of scientific analysis pioneered in the 1960s (Coope and Osborne, 1968), but only properly developed in the past twenty-five years is the analysis of insects and parasites to elucidate episodes of climatic and environmental variability, as well as human and animal pathologies (Bouchet et al., 2003; Coles, 1988; Elias, 2006, 2010; Greenwood et al., 2006; Kenward et al., 2000*a*, 2008; Whitehouse, 2006). This chapter is by no means an exhaustive description of the various disciplines, but rather highlights some of their methodological approaches, comparing them with the results obtained in a number of projects.

Part of the chapter also deals with dating techniques used in wetland archaeology, which, in fact, do not differ from those used in conventional dryland archaeology. For instance, thanks to the large amount of well-preserved timber, the most widely used dating method is dendrochronology; it has been the large quantity of wooden structures found in marshland and lacustrine settlements that has mostly contributed to the development of some of the main dendrochronological sequences in Europe (Baillie, 1995; Pilcher et al., 1984). Some of these sequences are extremely reliable ($\pm$ one year) and they reach back thousands of years (see e.g. that of southern Germany—*c.*11,000–12,000 years) (Becker, 1985, 1993; Billamboz, 2004, 2005; Schaub et al., 2008). As is the case with geoarchaeology, so also dendrochronology works very closely with archaeobotany. The discipline is used not only for dating, but also for palaeoenvironmental reconstructions, especially concerning ancient forest management (Billamboz and Köninger, 2008). Furthermore, dendrochronological studies are tightly interwoven with radiocarbon (^{14}C) dating, especially for creating dendrochronological floating sequences (wiggle-matching), where the master sequence (from the present) is not available (Martinelli and Kromer, 1999). At the same time, radiocarbon needs dendrochronology

for calibrating its dates (Reimer et al., 2004, 2009). Another effective dating technique used in wetland archaeology is lacustrine varves. This method, developed by Baron De Geer (1912), more than a century ago, has proved to be extremely precise, although limited to particular areas only. However, in optimal conditions, it can achieve astonishing results (± one year, as dendrochronology), extending its range of dating far beyond the dendrochronology limits (Kitagawa and van der Plicht, 1998).

The chapter's final goal is to show how synergistic collaboration between the various disciplines has achieved remarkable results in recent years. For this purpose, two case studies, namely the current research in textile studies and the remarkably well-preserved lacustrine settlement of Arbon-Bleiche 3, Lake Constance, have been selected.

ARCHAEOBOTANY AND WATERLOGGED ARCHAEOLOGICAL CONTEXTS

Waterlogged archaeological assemblages often retain large amounts of well-preserved micro- and macro- subfossil botanical remains. These are vital for detailed palaeoenvironmental reconstructions as well as a comprehensive understanding of subsistence and economic strategies, including plant gathering, cultivation, animal fodder procurement, and woodland management. However, if randomly collected and carelessly handled, archaeobotanical remains may lose their value significantly, hence compromising the credibility of final interpretations. When planning archaeobotanical analyses for an archaeological project, it is therefore crucial to consider all possible variables (from sampling to analysis strategies) well before the excavation itself begins.

A thorough understanding of two distinct yet tightly interwoven processes such as taphonomy and preservation is essential for a correct recovery, identification, and interpretation of the archaeobotanical remains. Most botanical remains become part of the archaeological deposits as secondary refuse, a composition of organic material discarded intentionally. Primary refuse (intentionally and unintentionally deposited elements of a specific activity) also occurs but is less common (Jacomet and Kreuz, 1999; Schiffer, 1987). A sharp distinction between the two above-mentioned types of refuse assemblages is sometimes difficult to make. However, the way in which plant macro-remains enter the various assemblages should be (with good preservation) easily recognizable. They could be from animal fodder or crop processing, parts of house structures (e.g. roof thatching, or chaff in the wall and floor plastering), remains of food, components of animal or human faecal

remains (van der Veen, 2007). Parts of macro-remains, but in particular micro-remains (e.g. pollen) can also have allogenic origins; they have, in other words, been brought in involuntarily by atmospheric elements (wind, rain, or periodic floods). Amongst all these dynamic processes, a vital role is played by preservation, which, as described in Chapter 5, depends not only upon the various materials, but also on soil geochemical composition, together with the climate and hydrology of the area (Corfield, 2007; Wilkinson and Stevens, 2003) (see also Ch. 5 and Fig. 5.17).

One of the most important aspects of archaeobotanical studies (especially with waterlogged sites) is to adopt the right sampling strategy. Although there are some standard procedures to follow, it has to be pointed out that not all archaeological sites are suitable for them. It all depends upon the size of the excavated area, the type of site (single house or settlement), and the location (dry or wet terrain, or even under water). However, a few important factors should always be considered when sampling a waterlogged archaeological site (e.g. a settlement) with a potentially large quantity of botanical remains: (*a*) the density of the samples; (*b*) volume; (*c*) type of sample; (*d*) type of sediment; and (*e*) stratigraphy (Jacomet and Brombacher, 2005*b*).

The density of sampling has a significant influence on the final results. Surface samples should be collected from all areas and layers of the excavated grid, making sure that the various layers (or occupations) are distinctly separated. Sampling can also be done by profile columns (cores). The advantage of this strategy is much more secure stratigraphic control. However, the limited diameter of the column results in a smaller quantity of sampled material, hence risking the exclusion of important taxa. A dense network of profile columns, as the one adopted in Hornstaad-Hörnle 1A (Dieckmann et al., 2006; Maier and Vogt, 2001), might be an alternative solution to the problem. The volume of the samples is important too, because it influences the diversity and density of the botanical remains. One of the best options is large (5–10 litre) bulk samples, possibly complemented by smaller sub-samples (about 1 litre) for the identification of smaller items, before coarse sieving. The extraction of small samples (about 1 cm^3) for micro-remains (e.g. pollen) analyses from bulk samples or profile columns is usually done before the entire matrix is sieved or washed over. During the excavation it is also important to take some judgement samples that may include a specific event (e.g. burnt layers, remains of coprolite, etc.). Identifying the type of sediment (lake marl, clay, organic material, etc.) that the botanical remains are in is also crucial, as it may influence the taxa represented and consequently the final interpretation (Jacomet and Brombacher, 2005*b*; Jacomet et al., 1989). Stratigraphic control of the sediments in the samples is crucial, especially in sites with multiple occupations. In addition to the exposed profiles of the excavated area, profile columns (ideally covering land and water transects—see also geoarchaeology below), should also be collected. Sampling techniques in archaeobotany are

key, and, because of the close relationship with geoarchaeology (including micromorphology) (Goldberg and Berna, 2010), they highlight the importance of using the one-for-all sample technique, whereby a profile column (or other type of sample unit) is used for both disciplines and possibly for others too (e.g. small fish bones for archaeozoological analysis).

An important role in archaeobotanical studies of waterlogged sediments is played by processing methods to extract the plant remains from the surrounding matrix. Unlike for micro-remains (e.g. pollen), the methods for processing macro-remains are not standardized, and the various techniques are unfortunately not suitable for all remains. For instance, fragile items may be destroyed or unintentionally discarded if the cleaning and extracting process is too abrupt (Hosch and Zibulski, 2003). Although largely in use already in the 1970s and 1980s (Kenward et al., 1980), and despite its efficacy, the wash-over method is still not routinely applied. The over-compacted character of some waterlogged sediments requires a pre-treatment to facilitate the wash-over process. A series of experiments have identified the freezing and slow thawing method as the most suitable one for highly compacted sediments (Vandorpe and Jacomet, 2007). Particular attention should be paid to deposits rich in coprolite, which is sometimes difficult to distinguish from the surrounding inorganic matrix (Akeret and Rentzel, 2001). The sieve mesh-size adopted also plays a crucial role. The use of too large a mesh ($>$ 0.5 mm), for instance, can compromise the identification of important taxa, such as opium poppy seeds (*Papaver somniferum*) (see Fig. 6.1). Temporary conservation of archaeobotanical remains between the sieving and the identification process is vital. Recent research (Tolar et al., 2010) shows that the remains should never be dried (unless they are carbonized). The drying process can damage and destroy delicate specimens such as linen (*Linum usitatissimum*) and poppy (*Papaver somniferum*).

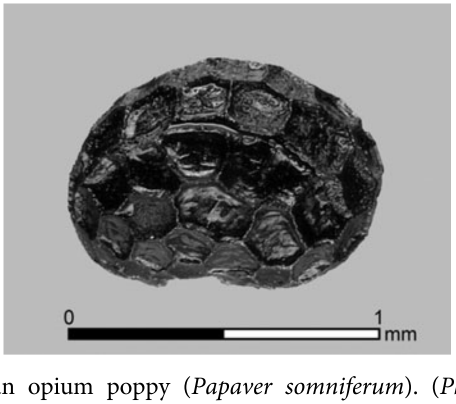


Fig. 6.1. Seed of an opium poppy (*Papaver somniferum*). (*Photograph*: courtesy of Stefanie Jacomet, IPNA, Basel University, Switzerland)

Once the botanical remains are extracted from the sediments, cleaned, and identified, they are ready for interpretation, which could range from palaeoenvironmental reconstructions to palaeoeconomy, both strictly linked to agricultural practices, subsistence, diet, plant domestication, migrations, and trade networks, to mention but a few. It is, for instance, thanks to archaeobotanical studies that it is possible to detect traces of plant domestication as early as the PPNB period (*c.*8500 cal BC) in the Fertile Crescent (Coppers and Bottema, 2002; Zohary and Hopf, 2000), or reconstruct the gradual northwesterly spread of farming from the Middle East (Barker, 2006; Brown and Jones, 2001; Colledge and Conolly, 2007). Questions to be asked can be very broad or extremely detailed. Light can be shed, for example, on the relationship between production and consumption (e.g. to distinguish between production sites and consumption sites) (Bakels, 2001; Wilkinson and Stevens, 2003); cultivation techniques (e.g. intensive use of manured plots, or shifting cultivation, including the slash-and-burn technique) (Bogaard, 2004; Jones, 2002); the seasonal aspect of cultivation (winter/summer crops) (Brombacher and Jacomet, 1997; Jacomet, 2007), or even on crops combined for reasons of higher productivity (see the Mesa Verde National Park experiment, Ch. 7). Through the analysis of stomach contents of the bog bodies' last meals, light can also be shed on subsistence strategies and diet preferences, which in some contexts may be linked to mortuary practices, offerings, and possibly even to sacred rituals.

The potential of archaebotanical studies is enormous, but in some cases interpretation of the results should be approached with caution. Due to the delicate nature of the remains, what becomes preserved and available to archaeologists is only part of the real picture; hence a thorough consideration of taphonomical processes is germane to avoid biased interpretations (Jacomet and Brombacher, 2005*a*, *b*). The difference in data availability between dry and waterlogged sites is overwhelming. It is, however, wrong to separate them as two distinct entities. Agriculture practised by people living in the wetlands was not different from that of the communities in drier areas. It is the quantity of what has been preserved that is different. Archaeobotanical research has been progressing significantly in recent years, bringing forward new tools of analysis and interpretation. However, there is still an urgent need for more standardized sampling strategies in order to facilitate more comparative multidisciplinary-based analytical approaches.

ARCHAEOZOOLOGY: WET VS. DRY SITES

The solid establishment of archaeozoology within mainstream archaeology is the result of the discipline's great potential to shed light on crucial issues,

spanning from basic socio-economic activities (e.g. subsistence strategies), to less profane social practices such as rituals, offerings, and mortuary traditions. As the subheading implies though, the extent to which this potential can be exploited depends upon the availability of data that is itself strictly linked to complex taphonomic processes. Although not necessarily always the case (see Ch. 5, under 'Preservation', and Ch. 4, 'Bog Bodies'), osteological assemblages (animals in particular) are far richer in waterlogged archaeological contexts than are dryland ones. Some of the best examples of thoroughly researched animal bone remains (mainly prehistoric) are found in central and northern Europe and Scandinavia, eastern Baltic Sea regions, western Russia, the Circum-Alpine region, New Zealand, and North America (in particular the Northwest Coast and Florida).

Archaeozoological studies vary significantly, from 'simple' morphological analyses to identify species, sex, and age, to more sophisticated statistical calculations to ascertain socio-economic relationships. In some exceptional cases, where the stratigraphic composition of the anthropogenic layers allows it, it is even possible to make a distinction between percentages based on bone-fragment numbers, and bone-find concentrations. This can be rather advantageous, especially concerning the distinction between wild and domestic animals, as is the case with some of the prehistoric lacustrine settlements of the Circum-Alpine region. Here it is known that, contrary to percentages, bone-find concentrations of domestic and wild animals do not influence each other (Schibler, 2004). As a result, it is possible to gauge the fluctuation (increase and decrease) of exploitation between the two type of animals (Stöckli, 1990*a*). Furthermore, by calculating the number of bones per square metre of each anthropogenic occupational phase (rather than the volume of each layer), it is possible to avoid the problem of determining the exact volume of each layer, which, itself, may be distorted by compression or erosion and therefore not reliable (Schibler et al., 1997*b*).

As is the case for other disciplines, so it is with archaeozoology that the best results are often obtained by synergetic collaboration with other disciplines (see Box 3.1). The process of integrating archaeozoological research into multidisciplinary projects is facilitated by the fact that archaeozoology is already, in itself, an integrated discipline, able to go beyond traditional boundaries between science and humanities (Albarella, 1999; M. Maltby, 2006).

An area of research particularly prolific is the study of hunting tools, with a special emphasis placed upon hafted bone points. Thanks to the large amount of such artefacts found in some lacustrine sites (e.g. Arbon-Bleiche 3, see Box 6.2) (Deschler-Erb et al., 2002; Leuzinger, 2000), it is even possible to apply explorative statistical calculations, such as the correspondence analysis, which, combined with morphometric measurements and spatial distributions, allow for the determination of the artefacts' specific function (e.g. arrowhead,

or pointed tools), and its connection to different hunted animal species (Schibler et al., 2010).

The holistic aspect of archaeozoology stretches the discipline's range of research far beyond empirical functionalistic purposes. One of the best examples within wet/wetland archaeological sites is the study of the Lundby Bog (Denmark) kettle-hole fauna remains (elk). Here, not only have archaeozoological analyses proved that the assemblages were part of organized hunting expeditions away from permanent settlements, but, thanks to particular remains (e.g. the intentionally perforated elk shoulder blades), being studied within an ethnographic context (the present-day Sami hunting groups of the Lapland regions), it has even been possible to identify hunting rituals that have been perpetuated through millennia (Møller Hansen, 2003: 103–4).

As with other disciplines discussed throughout the chapter, so also for archaezoology is a systematic sampling strategy germane for obtaining positive final results. This is particularly true concerning, for instance, the study of fish remains, often overlooked during excavations. The use of a single sample for all disciplines (the one-for-all sample technique; see 'Archaeobotany and Waterlogged Archaeological Contexts', above), and the improvement of recovery techniques (e.g. wet sieving, flotation, etc.), have facilitated the identification of unexpected quantities of fish bones, changing, for instance, biased theories about fish consumption within prehistoric Circum-Alpine region lacustrine populations (Hüster-Plogmann, 1996, 2004) (see also Box 6.2).

Finally, because of the myriad of different taphonomic processes, as well as unequal levels of preservation, it is important to acknowledge that archaeozoologists are often dealing with significantly different quantitative and qualitative data. A wide gap exists in particular between waterlogged and dryland site fauna remains. However, it is by integrating archaeozoology into a broader theoretical discourse, hence triggering more interdisciplinary research, that seemingly insurmountable obstacles will eventually be overcome.

ANCIENT DNA IN WATERLOGGED ARCHAEOLOGICAL REMAINS

Since the development of ancient DNA (aDNA) studies some twenty-five years ago, archaeologists (and/or archaeogeneticists) have always been tempted to exploit the great potential of genetics, to explore uncharted territories of human studies, which had hitherto remained shrouded in mystery. In addition to answering straightforward questions concerning species identification (both fauna and flora), aDNA studies can also shed light on more

complex issues, ranging from human evolution and migration to animal and plant domestication.

Despite the excellent preservation of organic materials found in waterlogged archaeological contexts, aDNA sequences are more difficult to obtain from these remains than from seemingly poorly preserved ones in dryland environments. Under normal circumstances, DNA deterioration is caused by microbes and autolytic, hydrolytic, and oxidative processes (Pääbo et al., 2004). Favourable environmental conditions such as an absence of oxygen, very dry environments, low temperature, lack of UV radiations, a total absence of micro-organisms, and a neutral or slightly alkaline pH content, may, however, limit hydrolysis and prevent microbial and chemical action, thus reducing DNA degradation.

Within lacustrine areas, for instance, apart from the successful amplification of glutenin subunit genes from charred wheat of the ZH-Mozartstrasse Neolithic lake village (Schlumbaum et al., 1998), the numerous attempts to extract aDNA from wild or domestic animals from various lake-dwelling settlements in central Europe and Ireland (Bernicchia et al., 2006; Larson et al., 2007; Mcgahern et al., 2006; Pruvost et al., 2008) have all failed. Even the initial optimism with the ‘perfectly’ preserved human brains of Windover (Florida, USA) faded away after a few attempts (Doran et al., 1986). More disappointment comes from the bog people remains, which, despite their morphological intactness, do not usually yield any DNA; low pH and tannic acid from the bog vegetation degraded it almost completely.

Amongst all these negative results, there are, however, a few examples of successful extraction of aDNA from waterlogged plant remains. See, for instance, the *Prunus* fruit stones from the Roman *vicus* of Tasgetium, Eschenz (Switzerland) (Pollmann et al., 2005), and a few more examples from grape seeds and cherry and olive stones (Cappellini et al., 2010; Elbaum et al., 2006; Manen et al., 2003). Since all these seeds and fruit stones have a characteristically hard ligneous protective covering, it is possible that this was the protection that prevented a complete decay of the DNA (Schlumbaum, pers. comm. 2010).

Environments that are particularly favourable to an optimal aDNA preservation are permafrost, glaciers, and ice cores. Examples from this field of research are numerous, ranging from the sequences of extinct mammoths from Siberia (Gilbert et al., 2007), the entire genome of a palaeo-Eskimo (Rasmussen et al., 2010), and the identification of domestic goatskin as leather material of a Neolithic legging found at the Schnidejoch glacier in the Swiss Alps (Schlumbaum et al., 2010), to the reconstruction of vegetation history from deep ice cores in Greenland (Willerslev et al., 2007).

Despite the above-mentioned limitations due to preservation in waterlogged conditions, aDNA analysis has great potential, especially concerning the establishment of plant cultivars (Schlumbaum et al., 2008). Recognition of

geographical origins of grapes and oak timber, through microsatellite typing and geographically structured chloroplast markers, have already been successfully attempted (Cappellini et al., 2010; Deguilloux et al., 2006). A better understanding of waterlogged site formation processes, along with the improvement of new aDNA extraction and amplifying techniques (in particular next generation sequencing (NGS)), will certainly open new perspectives within this fascinating yet still fairly unexplored discipline.

GEOARCHAEOLOGY AND WET SEDIMENTS

The highly dynamic character of wetland landscapes and wetland geological sediments highlights the importance of geoarchaeology in order to identify archaeological sites, buried palaeo-landscapes and other evidence of people–environment interaction. A full understanding of stratigraphic deposits from a geoarchaeological perspective is crucial if we want to know why, for example, the remains of entire palaeo-forests are sometimes found buried along our coasts (Bell, 2001, 2007; Coles and Hall, 1998; Hall and Coles, 1994*b*); Preboreal lacustrine occupations in southern Scandinavia are found beneath layers of deeply buried peat deposits (L. Larsson, 1998, 2001); lack of artefacts near fish-trap sites along the Alaskan rivers does not mean a total absence of settlements nearby (Chaney, 1998); some of the pre-European weirs along the Coquille River in Oregon (United States) are no longer near the river banks (Ivy and Byram, 2001); or, finally, thick stratigraphies on some of the Circum-Alpine region lake shores (see Fig. 6.2) (Gross, 1987) often retain complex anthropogenic layers that do not always reflect clear multiple-phase occupations.

Adopting a sound sampling strategy is vital when reconstructing palaeo-environments. If reconstructions are based upon a single core from the deepest part of a wetland basin, it may well provide us with the palaeo-vegetational development of the region, but at the same time tell us very little about people–wetland interaction. Of much greater importance is the interface zone between wet and dry ecosystems, where people would have dwelled more often. As a result, transect sampling, covering both zones (wet and dry) would produce a much more complete picture of the past landscape and the effect of human influence upon it.

Change in climatic conditions alters the hydrological balance of the wetlands. This instability is very much reflected in the soil, which often reacts differently from organic materials or artefacts found in the same wetland context. In fact, the development of soil may be hindered by waterlogging and leaching processes, making traces of land-use signature features less evident and/or distorted. This is particularly true in ‘originally’ dry areas, which have experienced an increase in humidity accompanied by flooding

Fig. 6.2. The more than 2-metre thick stratigraphic sequence (from the Neolithic to the Late Bronze Age) of ZH-Mozartstrasse, Lake Zurich, Switzerland. (*Photograph*: Daniel A. Berti, courtesy of the Amt für Städtebau, Unterwasserarchäologie Zürich, Switzerland)

and subsequent waterlogging. One of the best examples (also one of the best studied) is the Fengate basin in north-western Cambridgeshire, England (Coles and Hall, 1998). From the second millennium cal BC up to the late Middle Ages, the area experienced a progressive rising of groundwater tables, which inundated vast parts of dry terrains, hence hindering soil development (French, 2003; French and Pryor, 1993). Pedological analysis has shown that although some features, such as alluvial soil and peat, are well preserved in the stratigraphy, they lack micro-details (e.g. land-use processes), because they have been distorted and flashed out by flooding and waterlogging processes (French, 1988; Macphail et al., 1990).

An even more significant problem concerning prehistoric palaeosoils is found in coastal environments. Because of marine inundations, especially in estuaries, dryland areas change to intertidal conditions. As a result, wooded terrestrial soil becomes dispersed under the influence of sodium ions and

deteriorates rapidly (Allen and Gardiner, 2000; Macphail, 1994, 2009). A similar situation is registered in raised and blanked peatbogs, where humic-iron pan formation causes saturation and acidification, which, along with leaching, leads to severe depletion of buried soils (Balaam et al., 1982).

River valley systems, on the other hand, are influenced differently by flooding and waterlogging processes, which themselves depend upon a number of factors such as climate, geology, and topography (Goldberg and Macphail, 2006). Processes of alluviation may, for instance, influence the soil to the extent that drainage properties are altered. Moreover, iron-rich groundwater may lead to pan formation and over-saturation. Subsequently, in post-flood drying conditions, the soil becomes excessively solidified, making the land difficult to cultivate (especially with unsophisticated agricultural tools) (French, 2003).

Natural and anthropogenic stratigraphies on lake shores are often influenced by the fluctuations (transgressions and regressions) of the lake level. Intensity and frequency of water-level variations do not depend only on short- and long-term climatic oscillations but also on the hydrological sensitivity of the lakes themselves (Magny, 1992: 328). A lowering of the lake level exposes previously deposited sediments, which may subsequently be re-covered by alluvium deposits, or even eroded. On the other hand, by water-level transgressions, the occupational layer(s) (during, or shortly after the occupation) can be influenced in two ways; (*a*) they can be quickly inundated and covered by fine-grained deeper water deposits (lake marl); or (*b*) if the water rises slowly, the effects can be destructive (e.g. erosion can be caused by wave action) (Goldberg and Macphail, 2006: 114). Especially in the latter case, anthropogenic deposits can be severely disturbed, altering the chronological order, or creating extra anthropogenic layers, which may look like a new occupation, but they are simply reworked debris of the same occupation redeposited later (Ismail-Meyer and Rentzel, 2004) (see also Box 6.2, below).

Although waterlogged geological deposits have great potential for the identification of past landscape-use, the reconstruction of palaeoenvironments, and the understanding of human occupational patterns, their interpretation must be approached with caution. Hydrological imbalance of the area, flooding, and waterlogging processes may alter the soil structure to the extent that precious information may be obscured. New advances in geoarchaeological and micromorphological analysis on water-saturated sediments as well as experimental studies on site formation processes such as deposition, trampling, and preservation (Bell et al., 1996; Krauss et al., 1999; Lillie, 2007; Rentzel and Narten, 2000) have already shed new light on these limitations, with possible alternatives as to how to overcome them. What has become clear, however, is that the efforts should not be concentrated only within the wetlands in *sensu strictu*, but expanded to those interface (dryland–wetland) areas and surroundings where human impact would have been more pronounced.

PALAEOCLIMATOLOGY: CLIMATE CHANGE AND HYDROLOGICAL IMBALANCES

Without adopting a too environmental-deterministic view, it is fair to admit that palaeoclimatological variations have always played a crucial role in shaping the evolution of past societies. Soon after the very first archaeological discoveries and excavations, archaeologists began to wonder whether environmental conditions in the past had been similar to or different from those of the present. It soon became evident that the second option was the more plausible; to prove it, however, was not going to be an easy task. The first breakthrough was triggered by the fierce lake-dwelling dispute (also known as the *Pfahlbaumproblem*—see also Ch. 1), in the first decades of the twentieth century. Irrefutable evidence showed that first, not all lacustrine settlements were built on stilts, and second, that occupational patterns followed, in some cases, the fluctuations of the lakes levels (Magny, 2004*a*, *b*; Menotti, 2001*a*). Encouraged by these discoveries, and urged by the need for a better understanding of past climatic conditions, systematic research began in various parts of Europe. From the 1960s onwards, synergetic efforts between archaeologists and palaeoclimatologists led to the establishment of a more precise climate history of the entire Holocene (Berglund et al., 1986). In the past three decades, palaeoenvironmental and palaeoclimatological reconstructions have become an integrated part of major wetland archaeological surveys and excavations all over Europe (e.g. the Somerset Levels Project, the Fenland Survey, the Humber Wetland Project, and the North West Wetland survey in England; the numerous peatbog excavations in Ireland, northern Europe, and Scandinavia; and finally the large number of lake-dwelling excavations in the Circum-Alpine region), and in various other parts of the world (China, Japan, New Zealand, North and South America).

One of the most important meteorological aspects in palaeclimatology linked to wetland environments is precipitation, which determines the hydrological balance of particular geosystems formed by rivers, mires, lakes, and peatbogs. Patterns of palaeohydrological change at a regional and supra-regional scale are therefore relevant to the reconstruction of past climate variations. The reconstruction of past water-level fluctuations can be achieved in different ways. For instance, concerning changes in lake levels, one of the most commonly used methods is plant microfossil analysis, aimed at reconstructing changes in spatial distribution of aquatic vegetation belts that reflect water depth; lower water depth produces a spread of macrophytes, whereas higher water levels result in the macrophytes' displacement (Digerfeldt, 1986). The sampling strategy for this type of analysis is core transects (perpendicular to the shore), and the area sampled should cover both the 'dry' shore and the submerged one. In lakes rich in carbonate lake marl, another useful method to

determine water-level fluctuations is to measure the variations of carbonate concretion morphotypes. In fact, each morphotype has a specific spatial-depth distribution (extending from the shore to the end of the morainic shoal), in relation to water depth and aquatic vegetation (Magny, 2006). Mollusc assemblages, chironomids, diatoms and cladocera, and isotope analysis (Clerc et al., 1989; Hammarlund et al., 2003; Korhola et al., 2005) are other methods successfully used to reconstruct palaeo-lake-level fluctuations.

Increase in precipitation and alteration of the water-table also affect mires and ombrotrophic peatbogs. These variations can be spotted in the change in humidification of organic deposits, changes in the macrofossil stratigraphy (see e.g. the shift from dry to wet climate conditions during the Sub-boreal–Sub-Atlantic transition—*c.*2750 cal BP—in the Netherlands) (van Geel et al., 1996), and variation in testate amoebae assemblages (Charman et al., 2007). Coring in deeper areas of the studied water basins can also be of great help in identifying hydrological variations. For example, geochemical (XRF) and mineralogical analysis of deep cores can identify allogenic detrital inputs (e.g. from rivers), which may indicate an increase in river water discharge due to more precipitation or erosion activity as a result of human impact on the landscape (see Arbon-Bleiche 3, Box 6.2, below). Moreover, deep cores provide useful information on chironomids, oxygen isotopes, and pollen, which are all valuable proxies for the reconstruction of palaeoclimatic records (Heiri and Millet, 2005). The presence of micro-particles of charcoal would furthermore provide useful information on both climatic variability and human impact on the vegetation (Vannière et al., 2008).

Fluvial deposits too are a rich source of data that enables us to shed light on palaeoclimatic change and anthropogenic influence on the landscape. Their typological classification (shape, length, and size) offer invaluable insights into their diachronic evolution in relation to the possible nearby human activity (e.g. distance from the settlement and type of exploitation) (Arnaud et al., 2005; Bravard and Magny, 2002).

High-resolution palaeoclimatic records can be extremely useful to archaeologists, but they can only be achieved with a synergetic collaboration between the two disciplines (archaeology and palaeoclimatology). The availability of dendrochronological dating (e.g. as in the case of the lacustrine villages of the Circum-Alpine region) can highlight even short and abrupt climatic instabilities (Arbogast et al., 2006). Moreover, multi-proxy data obtained from the same sample favour the reconstruction of common trends between the data, hence facilitating the identification of single environmental variations with different possible origins (cultural, natural, or both) (Magny et al., 2006*a*; Sadori et al., 2004). In addition to the same samples collected within the archaeological site, further transects in external areas, as well as deep cores in deeper parts of the water basin (which are more appropriate for certain proxies) may add extra data to the palaeoclimatic and environmental reconstructions.

The final goal of palaeoclimatological studies is to shed light on the delicate relationship between people and the environment. But how decisive was the influence of climate on human occupation in the wetlands? It has recently been argued that climate did not have a dominant control over human activity around the lacustrine regions of central Europe, during the Neolithic and Bronze Age (Arbogast et al., 2006; Pétrequin and Bailly, 2004; Zolitschka et al.). However, archaeological evidence, also supported by solar activity linked to atmospheric residual ^{14}C variation (see Fig. 3.5), shows a decrease in wetland occupation (especially around the Circum-Alpine region lakes) and agricultural activity during periods of unfavourable (wetter and colder) climatic conditions (Magny, 2004*b*; Magny et al., 2006*b*; Menotti, 2003, 2009; Pfister, 2001; Tinner et al., 2003).

Accepting that both factors, cultural and climatic, may have influenced human activity, there are still lacunas in both disciplines (palaeoclimatology and archaeology) that prevent scholars from drawing plausible conclusions. A more precise knowledge of subsistence strategies in relation to annual and seasonal activity, covering wetland as well as dryland communities, is therefore needed. Hence the importance of developing studies on different proxies that are able to identify climate change and temperature oscillations at a seasonal level (e.g. oxygen isotopes and chironomidae) (Magny et al., 2009). As demonstrated by a number of lacustrine settlements in the Circum-Alpine region, the interface of wetland and dryland areas and their inland surroundings were used by both wetland and dryland communities (Brombacher and Jacomet, 1997; Ebersbach, 2002, 2003). Hence the need for a more holistic understanding of social and environmental interactions between the two areas. Knowing that an increase in precipitation, along with lake-level fluctuations, influenced human occupational patterns within some lacustrine environments is not longer satisfactory. It is necessary to know whether climate change influenced inland environments and communities as well. Only a more detailed and holistic consideration of the various palaeoclimatic proxies will help achieve that goal.

INSECTS AND PARASITES AS PROXIES OF ENVIRONMENTAL CHANGE

Despite its great potential, the study of subfossil insect remains (also called archaeoentomology) found in waterlogged contexts is still quite restricted geographically. In fact, while well established in Britain and Ireland, the discipline is still underrepresented in a number of countries around the world, in spite of their fairly strong wetland archaeology research tradition (Elias, 2010). This may be due to various factors, such as different research

traditions, lack of specialized people, methodological research issues, inadequate sampling strategies, and restricted financial availability. Notwithstanding these difficulties, archaeoentomological studies are becoming routinely part of more and more archaeological excavations and analyses. But why are insect studies important? What kind of questions can they help us answer? Unsurprisingly the list is quite long. They can, for instance, shed light on changes in vegetation patterns, hydrological variation in wetland contexts, composition and structure of woodland areas, and climate oscillations on regional as well as supra-regional scales. Moreover, synanthropic insect assemblages can also tell us about living conditions in houses and/or villages, human activity in relation to the environment (e.g. agriculture, forest management, and animal husbandry) and diseases. It is obviously understood that not all archaeological assemblages can provide these answers; what can be achieved depends upon the type of wetlands, the character of human occupation, and the geographical location (Glaz et al., 2009; Howard et al., 2008; Kenward et al., 2008). Lacustrine environments are, for instance, different from peatbog areas, as much as riparian ecosystems may display dissimilarities from estuaries and coastal areas. Human occupation within these diverse ecosystems also varies substantially. Occupations directly on lake shores are more likely to be habitations (pile-dwellings, crannogs, duns, and island settlements), whereas anthropogenic evidence in bogs is more linked to trackways, alignments, and sacrificial offerings. At the same time, fluvial deposits (especially palaeo-channels) may provide excellent evidence of diachronic environmental change, but human action could be more difficult to interpret because synanthropic assemblages are often not available (A. G. Brown, 2008).

Archaeoentomological studies of lacustrine village assemblages are rather negligible. Despite the rich waterlogged assemblages of the Circum-Alpine region, this research area has, for some reason, not been fully exploited. An area of research that is currently developing is palaeo-parasite studies on coprolite. So far, palaeoparasitological research has focused on parasite biodiversity and distribution on the northern parts of the Alpine lacustrine region, with special emphasis placed on the surroundings of Lake Constance. The main goal is to shed light on the influence of parasite infestation during transition periods of cultural change and migrations during the fourth millennium BC (Le Bailly et al., 2007). Similar studies on parasite eggs in coprolite have also been carried out on the Maori *pa* of Kohika (New Zealand). The identification of *Capillaria hepatica* (common in rats) has helped identify the coprolite as dog excrement. Dogs would have caught *Capillaria hepatica* by eating rats, which were apparently common in the *pa* (Irwin et al., 2004). Although not with coprolite, parasite analyses have been also performed on the archaeological assemblages of the Roman *vicus* near Eschenz (where the Untersee becomes the Rhine, Switzerland). Here, well-preserved human lice

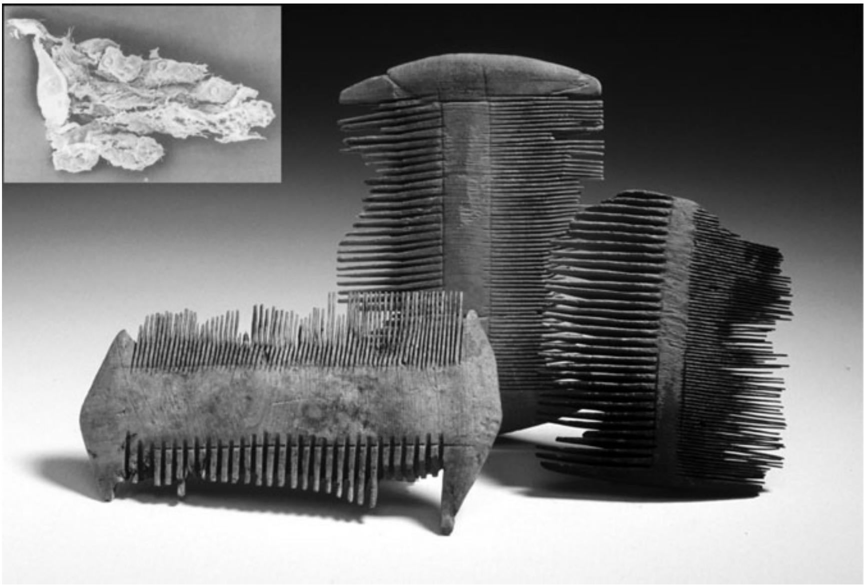


Fig. 6.3. Finely crafted wooden combs of the Roman *vicus* Tasgetium near Eschenz, Switzerland, and a well-preserved human louse (*Pediculus humanus*) (insert), found in a comb umpernater. (*Comb photograph*: courtesy of the Amt für Archäologie Thurgau, <www.archaeologie.tg.ch>; *louse photograph*: courtesy of Karin Wolf-Schwenninger, State Museum of Natural History Stuttgart, Germany)

(*Pediculus humanus*) were found between the teeth of finely crafted wooden combs (see Fig. 6.3) (Brem et al., 1999).

Good archaeoentomological research has been carried out at Buiston crannog, Scotland (Crone, 2000), where the presence of insects and parasites is clearly visible throughout four of the six main occupational phases. Apparent evidence of habitations is, for instance, noticeable in phases three and four, with the presence of the human louse (*Pediculus humanus*) and human flea (*Pulex irritans*), accompanied by a large number of houseflies (*Musca domestica*), suggesting fairly squalid living conditions (Kenward et al., 2000*b*; Skidmore, 2000). In the past decade, palaeo-insect studies of remains have also included Trichoptera and Chironomidae, which are often used for palaeoenvironmental and palaeotemperature reconstructions (Brooks, 2003; Greenwood et al., 2006; Langdon et al., 2004).

Since synanthropic insect assemblages are not often present in peatlands, archaeoentomological analysis within these ecosystems is more oriented towards identifying local and intra-regional natural environmental changes (vegetation change, hydrology, and climatic variations), rather than focusing directly on human action. One of the best examples of identification of climate change accompanied by episodes of flooding and groundwater instability is the work of Girling (1979, 1982, 1984) for the Somerset Levels Project. Similar

studies have also been carried out at Thorne Moors (Yorkshire, England) (Buckland, 1979) and at Derryville (Co. Tipperary, Ireland) (Reilly, 2005). Both sites revealed hydrological instability (flooding periods) proved by the presence of aquatic beetles. Moreover, the identification of the *Prostomis mandibularis* (a beetle that prefers rotten wood) implies the reuse of timber that had been lying on the ground for quite some time before being used for constructing the trackways (Reilly, 2009).

Because of their geomorphologic and ecological complexity, archaeoentomological studies of riparian environments are not as straightforward as those of lacustrine and/or peatbog ecosystems. Since floodplain deposits are often not entirely waterlogged, timber (e.g. from houses) is not always preserved. However, the identification of woodworms, as in the case of Mingies Ditch (Oxfordshire, England) (Allen and Robinson, 1993) may suggest that wooden constructions were present. Moreover, although lacking in synanthropic assemblages, palaeo-channels, often present in a riverine landscape, are quite useful to detect human action indirectly. Their organic accumulation may, in fact, reflect changes in woodland, agricultural practices, and even climatic variations (A. G. Brown, 2008; Davis et al., 2007).

Two types of environment particularly interesting for palaeo-insect analysis are estuaries and coastal areas. These ecosystems often include features similar to all the geological deposits discussed above (lacustrine, riverine, and peatland areas). The best case study is that of Goldcliff (Welsh side of the Severn Estuary), where remains of palaeo-channels, trackways, and house floors are all found in the same area. This is an invaluable opportunity to confirm (or disprove) the various results; for instance, the high diversity of synanthropes, which, rather than having been generated on site may partly or wholly have allogenic origins (Smith et al., 2000).

This brief account of archaeoentomological studies has listed but a few potentials of the discipline. Unfortunately, insect analysis is not as yet a routine part of wetland archaeological excavation, and this often compromises the completeness and the more holistic aspects of the final results.

DATING WATERLOGGED ARCHAEOLOGICAL REMAINS

Dendrochronology

Dendrochronology research has come a long way since the pioneering work of Douglas (1935) in the first decades of the twentieth century. Although the discipline (as a dating method) had, at the beginning, nothing to do with

wet/wetland environments, it was owing to the large amount of well-preserved wood subsequently found in waterlogged archaeological sites that dendrochronology has become one of the most reliable absolute dating techniques in archaeology (Baillie, 1982, 1995; Manning and Bruce, 2009). The great potential of dendrochronology in Europe was first realized by Huber following the first systematic excavations of the numerous lake-dwellings of the Circum-Alpine region and surroundings (Kaeser, 2008*a*). First working on single projects on Lake Dümmer (Hunte 1) and Lake Feder (Wasserburg Buchau) (Huber and Holdheide, 1942), then synchronizing several Swiss lakeside settlements, Huber (1967) set the basis for dendrochronology research in central Europe, which, thanks to the collaborative work of Becker et al. (1985), would eventually result in an 11,000-year-long oak and pine master sequence (Becker, 1993). The sequence was subsequently improved and extended to over 12,000 years by Friedrich et al. (2004). Due to the climate-orientated character of dendrochronology, sequences are often quite regionalized, with some difficulties in bridging the gaps between them. This is, for instance, the case between the northern and southern slopes of the Alps e.g. northern Italy, where dendrochronology building is still supported by wiggle-matching (Martinelli, 2001, 2005) (see below).

An important aspect of dencrochonology is that it is not limited to dating alone, but is linked to different research areas in archaeology and environmental sciences. Dendrochronology studies can shed light on socio-economic aspects, building technology, occupational patterns (settlement development, house construction, and building biographies), and, finally, environmental studies in relation to human impact on the landscape (climate variations and people's responses, as forms of adaptation). One of the major achievements of dendrochronology is the study of wood technology, which enables the identification of the genesis, development, and organization of the village. Not only is it now possible to reconstruct biographies of houses and villages, but also their organization in terms of wood used (different wood species for different buildings), provenance, and forest management. Good examples are the two Neolithic lake-dwellings of Hornstaad-Hörnle (1A and 1B); the first village consisted of small round wood houses used for a short period of time, whereas the second had larger and sturdier buildings occupied for longer (over a decade) (Billamboz, 2006). Dendrochronology can also help us identify possible diversification in social status within the village, or links between houses, in terms of families and households. At Bad-Buchau Torwiesen II (Lake Feder) for instance, different tree species were used to construct different buildings in the village over a timespan of four years (3283–3279 BC); two large oak houses were first built on the landward side, several ash dwellings were then constructed in the centre of the village, and finally two smaller willow and Scots pine houses were erected next to the water (Bleicher, 2009; Schlichtherle et al., 2010). Links between different houses can also be

recognized. For example, the use of parts of a single split log in five different houses of the Neolithic village of Pfyn-Breitenloo (3707 BC), Switzerland, shows the possibility of a single household encompassing more than one house (Leuzinger, 2007: 40–42). Even demography fluctuations can be identified in relation to wood typology coming from either primary or secondary forests (Arbogast et al., 2006; Hafner and Suter, 2000; Pétrequin et al., 2002; Pétrequin et al., 2005).

Dendrotypology has also been used to identify different practices of woodland management, by sorting wood according to different criteria (which are of course related to dendrochronology, wood technology, and dendrology), such as the growth rate of different trees, how the various wood species were selected, and the way the wood (e.g. the trunk or branches) was worked (Haneca et al., 2006). Following these criteria, two types of forest over-exploitation and degradation in the thirty-seventh century BC have, for example, been identified on the northern shores of Lake Constance. While inhabitants of Sipplingen and Ludwigshafen would use old oak trees, people on the Untersee (part of Lake Constance) would practise intense coppicing to cope with the scarcity of wood resources (Billamboz, 2010). Similar examples are also found on Lake Feder in the Bronze Age (Billamboz, 1997, 2003, 2005). Identification of wood procurements and forest management is also done at micro- and /macro-analysis level of charcoal remains. At Arbon-Bleiche 3 for instance, different types of wood were identified as used specifically for firewood, which was obtained from managed woodlands. It is interesting to notice that some tree species were purposely avoided as sources of firewood (Dufraisse and Leuzinger, 2009). Similar anthracological studies have also been carried out on some of the Neolithic lacustrine villages of Lake Chalain and Lake Clairvaux, showing the firewood procurement was very much an integrated part of the communities' socio-economic activities (Dufraisse, 2006; Dufraisse et al., 2007).

The regional character of timber species and their relation to climatic zones has also induced the development of a new research approach called dendro-provenance, whereby the origin of the timber is identified by comparative and correlation analyses of the tree rings, the wood species, and the timber spatial geographic distribution. This method is particularly used in Medieval and maritime archaeology in the Baltic Sea and North Sea regions (Rieck, 2003; Wazny, 2002).

Tree-ring studies have also been orientated towards more ecological perspectives in relation to climate variation (Schweingruber, 2001). Series of measured-growth tree-rings are evaluated in three different frequencies: high, mid, and low, and each of them has a specific aim. High frequencies are linked to intra- and inter-annual variations of the tree growth in relation to severe weather conditions. The mid frequency concerns short-term and cyclical climate variations (unfortunately often difficult to distinguish from

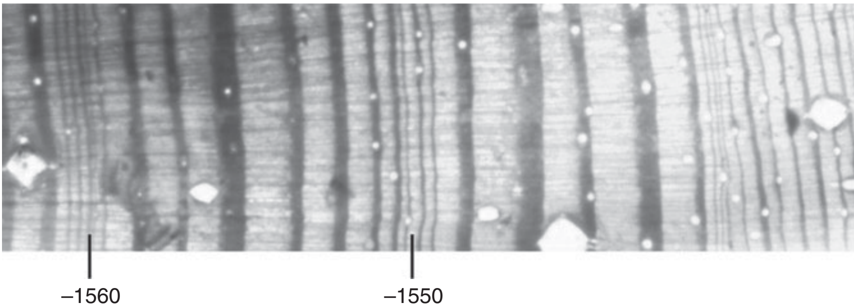


Fig. 6.4. Bog pine ring series from the Palisade of the Early Bronze Age lakeside village of Siedlung-Forschner (Lake Feder, Germany). The dates show two short-term depletions of growth due to excessive amount of water in the soil. (*Photograph*: courtesy of André Billamboz, Landesamt für Denkmalpflege Baden-Württemberg, Germany)

human-related influence). The tree-ring analyses within the mid frequency framework are able to identify anomalous tree-ring growth, which may be the result of 'sudden' climatic changes. A good example is the study of the Early Bronze Age Siedlung-Forschner village's palisade, whose bog pine piles show evidence of several short-term ring depletions (growth impediment—narrow rings), caused by an excess of wet conditions (see Fig. 6.4) (Billamboz, 1997, 2003). Dendrochronology evidence is in this case also corroborated by palaeoclimatological studies (Magny, 2004*b*; Magny et al., 2005).

Finally, the low frequency is linked to long-term change and may cover large regions. In this research framework, precisely dendrochronologically dated lacustrine villages can also be compared with solar activity reconstructed from isotope proxies. Palaeoclimatological studies have shown correlations between atmospheric residual ^{14}C variations and lake-shore occupation (Magny, 1993, 2004*a*) (see also above).

As has been seen, dendrochronology is no longer used merely as a dating method, but has also become an important tool in palaeoenvironmental studies, and is often utilized to corroborate the results of other disciplines, such as archaeobotany and palaeoclimatology. In some cases it may even shed light on socio-economic aspects of the various communities, their interaction with the surrounding landscape, and their response(s) to unexpected environmental variability.

Radiocarbon Dating

Thanks to the large amount of organic archaeological remains found in waterlogged contexts, ^{14}C dating is still the most applied dating technique in wetland archaeology. Although not as precise as dendrochonology, the

method is often used as a substitute for it where wooden material is scarce or a tree-ring master sequence is not available. Generally speaking, any organic sample can be ^{14}C dated, including insect chitin (Tripp et al., 2004). Pollen and even phytoliths (often found in water-saturated environments) could also potentially be dated, but (due to the very limited amount, e.g. < 0.2–0.5 mg), results are still not entirely satisfactory (Santos et al., 2009).

One of the major threats to ^{14}C dating is contamination, which may consist of human-derived contaminants, such as hair, fibres (e.g. from packaging), grease, and oil; or natural ones, mainly roots, or, especially in peatbogs, percolating humic acids, which may effect wooden remains and charcoal. Physical and chemical pre-treatments to eliminate these contaminants are essential in order to obtain reliable dates. The physical removal of contaminant is usually done using magnifying lenses and/or microscopes, whereas chemical methods vary according to the material. For instance, small amounts of carbonates are removed with the hydrochloric acid (HCl) treatment, while humic acid is usually eliminated with the sodium hydroxide (NaOH) treatment. Atmospheric CO_2 is also removed with acid wash. Finally, the isolation of alpha-cellulose, using multiple pre-treatment steps to eliminate the basic carbohydrate structure, is often required when dating old wood (Brock et al., 2010).

Where well-preserved wood is recovered, but for some reason, the master dendrochronology sequence is not available, high-precision dating is still possible with the wiggle-match technique (Bronk Ramsey et al., 2001). This method consists of taking samples from a sequence of relatively dated material (e.g. tree-rings, or superimposed peat), radiocarbon dating them, and fitting the results into the calibration curve using statistical methods (Galimberti et al., 2004; Kilian et al., 2000). If the wood to be dated contains sapwood (outermost ring), a fairly precise date (e.g. ± 10–12 years) can be obtained. Wiggle-match dating is used quite regularly in the southern parts of the Alps (northern Italy), where despite the large availability of wood in waterlogged archaeological sites the connection to the northern Alpine region tree-ring master sequence has, so far, failed (Martinelli, 2005; Martinelli and Kromer, 1999). This dating technology can also be of great help where there are distinct plateaus in the radiocarbon calibration curve (e.g. the so-called Hallstatt plateau, *c.*800–400 cal BC), which can cause high imprecision (more than three centuries) if the archaeological site falls within that period. In this case, wiggle-matching can be very useful, as demonstrated by Oakbank crannog (Loch Tay, Scotland). Despite the fact that the crannog chronology lies well within the Hallstatt plateau, it has been possible to obtain an absolute date, ranging between 495 and 480 cal BC, at 68.2 per cent probability (Cook et al., 2010).

Finally, it has become more and more evident that not only can peatbog and lacustrine sediments (in particular varves, see below) be extremely useful for improving the radiocarbon calibration curve (Reimer et al., 2009; Staff et al., 2010), but, with the help of Bayesian methods in conjunction with recently

developed depositional models (Bronk Ramsey, 2009), they may even offer new directions in the study of palaeoclimatic and palaeoenvironmental records within water-saturated stratigraphic deposits.

Varves

Since the Swedish geologist Gerard De Geer (1912) presented a 12,000-year-long geochronology, made of a series of annual layers deposited in a lacustrine context, at the eleventh International Geological Congress in Stockholm, varve chronologies have been applied to palaeoclimatological and archaeological studies quite regularly. Varves are the result of lake deposits caused by seasonal change in biogenic production, water chemistry, and inflow of mineral matter (see Fig. 6.5).

One of the advantages of this dating technique is that varves are annually deposited and, depending on the age of the lake, core sampling reliability, preservation, and other geological disturbances (erosion, alluvial, and colluvial

Fig. 6.5. Part of the varve sequence of Lake Suigetsu, Japan. (*Photograph*: courtesy of Hiroyuki Kitagawa, Nagoya University, Japan)

activity), they can extend back into the past for tens of thousands of years. As a result, natural as well as cultural events 'trapped' within them can potentially be dated very precisely (Lotter and Strum, 1994; Zolitschka, 1991). Varve sediments (from saline and freshwater to marine environments) are found in various parts of the world, with some of the best examples being those of Lake Holzmaar in Germany (Hajdas et al., 1995*b*), Lake Sopper in Switzerland (Hajdas et al., 1993), Lake Gosciaz in Poland (Goslar et al., 1989; Hajdas et al., 1995*a*), Lake Korttajarvi in Finland (Tiljander et al., 2003), Lake Van in Turkey (Landmann et al., 1996), Lake Sihailongwan in China (Schettler et al., 2006), and Lake Suigetsu in Japan (Kitagawa and van der Plicht, 1998, 2000; Nakagawa et al., 2005). Amongst them the best known is certainly Lake Suigetsu, where a 75-metre-long core, extracted in 1993, yielded an approximately 40,000-year-long varve chronology (Kitagawa and van der Plicht, 1998).

The great potential of varve sequences has been widely demonstrated. Not only can they offer an alternative dating tool to overcome the limitations of the more conventional dating techniques such as ^{14}C and dendrochronology, but their annually resolved physical, chemical, and biological information can contribute to the development of highly reliable palaeoenvironmental reconstructions (e.g. vegetation and climate). However, there are a number of factors that seriously limit their precision and reliability. One of the most crucial ones is, for instance, the identification of annual layers. In order for the dating method to be precise, the sequence should be free of disturbances and discontinuities. Despite the advanced techniques of identification (e.g. X-ray radiographs, thin-sections, high-resolution image analysis, backscattered scanning electro (BSE) microscopy, and the more complex use of algorithms) (Kitagawa and van der Plicht, 1998; Schaaf and Thurow, 1994), undisturbed sequences are extremely difficult to obtain. Anomalies and lacunas are often double-checked by cross-dating and multiple-core correlation of sediments from the same lake. It has to be pointed out, though, that hiatuses caused by natural calamities (e.g. earthquakes and/or floods) are very localized and may result in different morphologies even within a very limited area. Another method to verify the chronological validity of the varves is to identify known-age events, such as volcanic eruptions, abrupt climatic shifts, or other severe natural disasters (Fukusawa et al., 1994). For instance, recent sequences can be verified with tephrochronology, and ^{137}Cs and ^{210}Pb dating (Stihler et al., 1992). Older varve sequences, on the other hand, are more difficult to verify. The most common method is to date particular contents of the varves; for example, organic microfossils can be dated using high-precision AMS ^{14}C dating, whereas inorganic material could be cross-dated with other conventional methods such as thermoluminescence and uranium-thorium (Staff et al., 2010).

Miscounted layers in a varve sequence can result in missing (or additional) years. However, thanks to new counting and more precise techniques of layer recognition, varve chronologies can also be adjusted, as was the case of the

Lake Stopper sequence, to which 550 years were added after a re-evaluation (Hajdas and Bonani, 2000).

A great potential of varve chronologies is that they can be integrated into the radiocarbon calibration dataset in order to extend the calibration curve beyond the limits of dendrochronology (*c*.12,593 years) (Bronk Ramsey et al., 2006, 2001; Reimer et al., 2004, 2009; Schaub et al., 2008; van der Plicht et al., 2004). Calibration datasets of well-dated varve sequences are purely terrestrial and are not subject to variations, thus making the calibration more reliable.

There is still a large number of obstacles that have to be overcome in varve chronology, but more sophisticated methods of sampling as well as layer identification have the potential of revolutionizing dating methods in archaeology, improving precision and accuracy of absolute dates on a sub-decadal timescale, well beyond the Holocene boundaries.

SYNERGETIC EFFORTS

The large quantity of organic material usually found in waterlogged archaeological excavations allows for a profusion of scientific analyses. Each of these analyses may have a specific target (e.g. dating artefacts, identifying the origins of material, etc.), or may serve as an aid to support (or contradict) results from other disciplines (e.g. aDNA studies). The majority of the results are a combination of efforts by a number of different disciplines. For instance, palaeoenvironmental reconstructions are in most cases a synergetic work between palaeoclimatology, dendrochronology, geoarchaeology, micromorphology, archaeobotany, malacology, and archaeoentomology, in association with a variety of dating techniques (e.g. dendrochronology, ^{14}C, and varve chronologies). Boxes 6.1 and 6.2 show two typical examples of collaborative work between disciplines, dealing with well-preserved archaeological assemblages found in waterlogged contexts. Although they may have different objectives initially, both case studies highlight the importance of joint efforts in order to achieve a final common goal: a better understanding of our past.

Box 6.1 Textiles: Interwoven Efforts of Multidisciplinary Collaborations

Textiles are not only, in physical terms, the items closest to people (e.g. clothes), but they also involve a multitude of socio-economic issues. They often express our social status, age, gender, ethnicity, and religion. The enormous potential of the archaeological remains of textiles is often obscured by their scarce appearance in archaeological assemblages. This is usually due to their fragile

continues

Box 6.1 Continued

organic composition, which is not able to withstand the pressure of time in normal temperate climates. There are, however, special environmental conditions, such as waterlogging, extreme dryness, and frozen terrains that facilitate their preservation (Bazzanella et al., 2003; Rast-Eicher, 2008; Schrenk, 2004). Even with optimal preservation, though, the identification of descriptive features that enable archaeologists to place the various textiles into socio-economic, geographical, and chronological contexts is rather problematic. A synergetic combination of a number of scientific methods has helped overcome the problem, shedding important light on fibre identification, colour, decoration, conditions, size, textile structure, wear through use, construction techniques, and irregularities in the woven structure.

Identification Analysis

Apart from the various weaving techniques, two of the most important elements in a textile are the fibre and the dye. There are a number of scientific methods used to extract information from these two components. Microscopy, for instance, is usually good enough to distinguish between cellulose-based (e.g. plant), and protein-based (e.g. animal) fibres, if the textiles are in good conditions. However, with poorly preserved specimens the identification is not always straightforward, and it may require chemical/biological tests (e.g. solubility measurements) (Lambert, 1997). The distinction between hemp fibres and those of flax and nettle can also be problematic, but it can be overcome by a polarized light microscope, or the recently developed micro-fluorescence and micro-beam diffraction (Müller et al., 2006). Contrary to what was previously believed, a number of textiles were not originally colourless as they may appear when they are found in archaeological contexts, but natural dyes were often added to the fibres (Cardon, 2007; Vanden Berghe et al., 2010). Methods such as absorption spectrophotometry and high-performance liquid chromatography (HPLC) have obtained great results in identifying active ingredients of numerous dyes (Vanden Berghe et al., 2009; Walton, 1988).

Weaving in a Wider Context

Investigations of fibres and dyes go far beyond the mere identification of materials. They open up further research perspectives into wider socio-economic contexts at intra- and supra-regional scales, including agricultural practices, plant cultivation, animal husbandry, domestication, trade networks, and migrations. For instance, strontium (Sr) isotope ratios are of great help for the identification of the provenance of archaeological materials. It can be applied to both animal (including human) and plant remains, as is demonstrated by two recent studies: (*a*) the identification of the geographical origins

of tule (hardstem bullrush) and willow raw materials from textiles recovered in a few western Great Basin rock shelters and caves (Benson et al., 2006), and (*b*) the confirmation that the Iron Age Gerum mantle (Sweden) and the tubular garment of Huldremose (Denmark) were made of non-local, and a mix of local/non-local wool respectively (Frei, 2009; Frei et al., 2010, 2009). Provenance studies can also be applied to dyes, which are not only linked to local cultivation of plants that could have been used as dye source (e.g. elder and bedstraw), but also to long-distance trade, as shown by the muricid shell, which was used to produce Royal or Tyrian purple (Alfaro and Karali, 2008; Haubrichs, 2005; Reese, 2005). In fact, textiles dyed with the muricid shell purple have, despite its Mediterranean origins, been found in various parts of central and northern Europe, and even as far as Siberia.

Although, as discussed above, the extraction of ancient DNA from waterlogged organic material can be problematic (see 'Ancient DNA in Waterlogged Archaelogical Remains', above), aDNA studies have great potential within textile research. They can, for instance, identify ancient sheep breeds linked to different selections of fleeces, which, themselves, determine(d) the wool quality (Plowman et al., 2000); or shed light on the various properties of flax, in order to understand the extent to which flax cultivation and selection influenced textile production (Allaby et al., 2005).

Waterlogged archaeological assemblages that contain rich archaeobotanical and archaeozoological remains also allow comparative analyses between plant- and animal-based textiles. Crucial transitional periods (e.g. the Iron Age in central and northern Europe), within which the shift from plant-based textiles to wool textiles occurred, can be better understood. For instance, osteological analysis on sheep bones would be able to tell us whether the animals were kept for wool or meat, as the presence of a large number of adult individuals (especially castrated males) is a clear indication of wool production (De Grossi Mazzorin, 2004).

Textile Tools and Production

A comprehensive picture of textile production and its integration in a wider socio-economic context is hardly achieved without considering the tools and techniques with which textiles were (are) made. Tools can, for instance, shed light on the various stages of manufacture, from fibre production, to spinning of yarns, and weaving. Waterlogged archaeological assemblages play, in this case, a crucial role, since a large part of these tools are made of organic material (e.g. spindle shafts, see Fig. 4.27) and are therefore rarely preserved in non-waterlogged contexts. A thorough examination of tool morphology, distribution, technological characteristics, and wear caused by use, provides vital information on the scale of production, technology, and social interactions (Andersson, 2007). As a result, inferences can be made about the

continues

Box 6.1 Continued

organization and scale of textile production, including distribution patterns within single settlements and between different regions (Andersson et al., 2008). A crucial area of research that, in many cases, tests the validity of the results obtained from the various scientific analyses is experimental archaeology (see Ch. 7). The incomplete character of the archaeological evidence does not allow for accurate inferences on ancient material culture; function and performance of textile tools and fabrics may be, in fact, different from what the archaeological remains suggest. As a result it is only by testing carefully made replicas (tools, fibres, textiles, etc.) that their limits, qualities, and shortcomings will be satisfactorily understood. For instance, spinning experiments have shown that the quality of a finished product is influenced by both the size and diameter of the spindle whorls and the quality of the fibres (Mårtenssen, 2007; Mårtenssen et al., 2009).

Due to their delicate nature, textile remains are not found very often in the archaeological record. Yet, because of their intimate relationship to people, they retain precious information about crucial socio-economic and environmental issues. This information is not, however, always straightforwardly available, but has to be extrapolated from scanty evidence with the help of sophisticated scientific techniques. It is, therefore, with a synergetic collaboration between different disciplines and, above all, the integration of the results into the general archaeological corpus, that the potential of textile studies will be fully exploited.

Box 6.2 Arbon-Bleiche 3: Biography of a Prehistoric Lake Village

Amongst the approximately 1,000 lake-dwelling sites recorded in the entire Circum-Alpine region (Suter and Schlichtherle, 2009: 14), the Neolithic settlement of Arbon-Bleiche 3 (Lake Constance, Switzerland) is possibly the most thoroughly and extensively studied. The site is certainly one of the best expressions of fruitful synergetic collaboration between various scientific disciplines ever attempted, which was to reconstruct the biographical development of a prehistoric lacustrine village from its establishment to its destruction fifteen years later. It has to be pointed out, however, that the remarkable results have only been possible thanks to three important factors: (*a*) the exceptional level of preservation of the site; (*b*) the fact that the site was occupied only once, sealed by lake marl deposits soon after its abandonment, and not disturbed by human or natural (e.g. erosion) influences until excavated in 1993; and, finally, (*c*) the thoroughly and systematically planned sampling strategy adopted during the excavation (De Capitani et al., 2002; Jacomet et al., 2004; Leuzinger, 2000).

Environment, Chronology, and Biographical Development

Joint work between palaeoclimatology, dendrochronology, geoarchaeology (including micromorphology), archaeobotany, malacology, and archaeoentomology, has established that the village was constructed during a favourable climatic optimum (see Fig. 6.6) (Haas and Magny, 2004), in the first part of the thirty-fourth century BC. As usual, only a couple of houses were built at the beginning (see also Box 4.3, under 'Occupational Patterns and Territoriality'), the real construction boom occurred between 3381 and 3379 BC (see Fig. 6.7). A few more houses were built between 3378 and 3376 BC, and then no more (only repairs) until the village was destroyed by a severe conflagration and abandoned in 3370 BC (Sormaz, 2004).

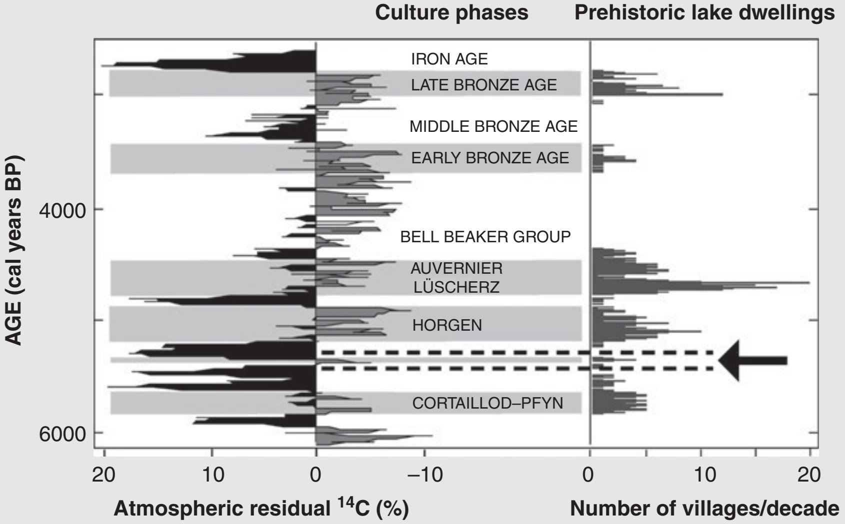


Fig. 6.6. Correlation between the atmospheric residual ^{14}C variations and the lake-shore settlement occupations in the northern part of the Circum-Alpine region, showing the favourable climatic conditions (arrow) during the occupation of Arbon-Bleiche 3. (*Graph*: courtesy of Michel Magny, Laboratoire de Chrono-écologie, CNRS, Besançon, France)

It is difficult to establish what caused the fire, but what is sure is that the settlement and the area have never been occupied since. In addition to a thorough study of the settlement's anthropogenic deposits, micromorphological analysis has been able to reconstruct even the biographies of

continues

Box 6.2 Continued

Fig. 6.7. Plan of the excavated Neolithic lacustrine village of Arbon-Bleiche 3, Switzerland, showing the chronological development of the settlement and the various house numbers. (Courtesy of the Amt für Archäologie Thurgau, <www.archaeologie.tg.ch>)

single houses. One of the best examples is that of house number 1 (the first house of the village in chronological order). After its construction in 3384 BC, organic material started to accumulate until the building (and only that building) was partially burnt in 3376 BC. The building was repaired in 3375 BC, but subsequently destroyed on purpose and the area used as a small animal pen (but only in winter), until the entire village burnt down in 3370 BC (see Fig. 6.8) (Ismail-Meyer, pers. comm., 2010). Detailed micromorphological analysis of the anthropogenic layer has even been able to determine that the thin stratum above the lake marl (deposited by the lake transgression), which accumulated straight after the village was abandoned, was not a subsequent occupation (as it might seem at a first glance), but a layer of reworked debris from the same village deposited by wave action much later (Ismail-Meyer, 2010; Ismail-Meyer and Rentzel, 2004) (see Fig. 6.8).

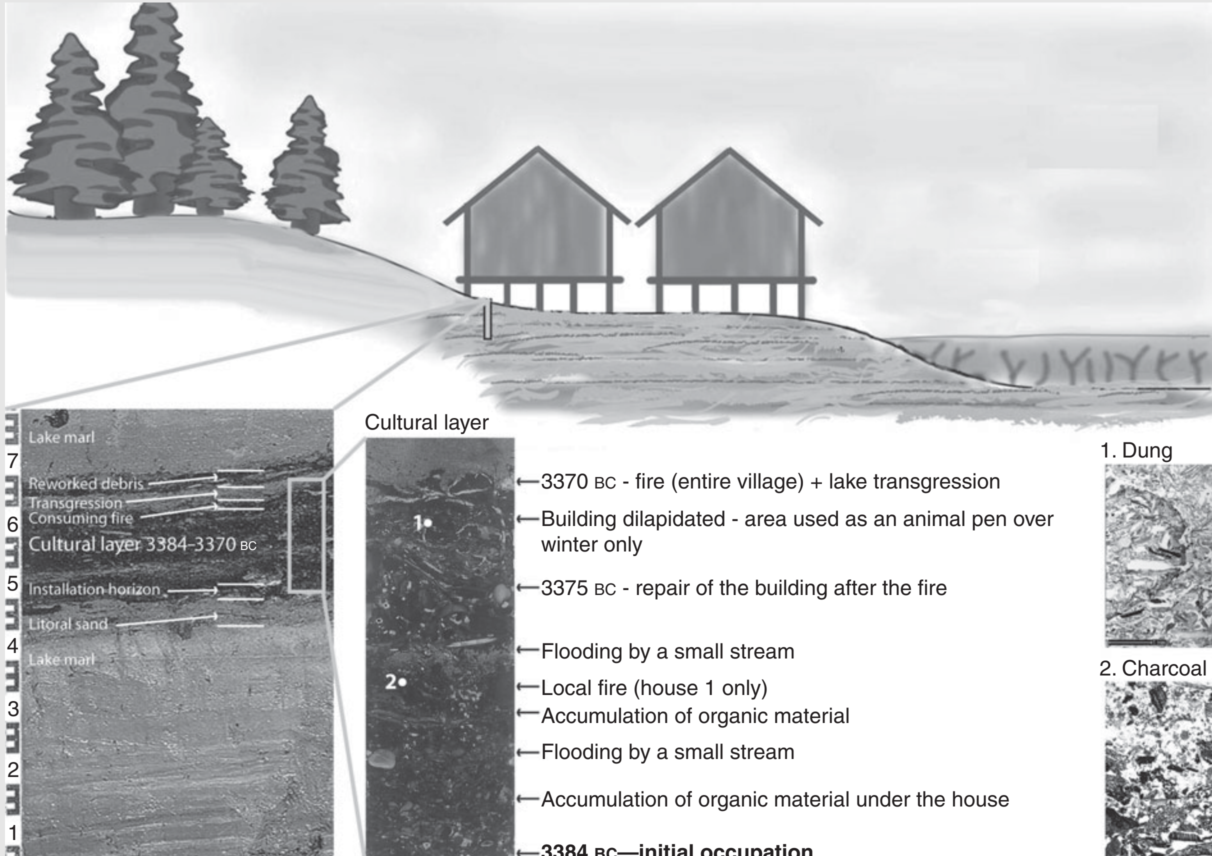


Fig. 6.8. Biographical development of house 1 at Arbon-Bleiche 3, obtained from micromorphological (thin-sections) and dendrochronological analyses. (*Graphic*: Ben Jennings and Kristin Ismail-Meyer. *Stratigraphy*: courtesy of the Amt für Archäologie Thurgau, <www.archaeologie.tg.ch>. *Thin-sections*: courtesy of Kristin Ismail-Meyer and Philippe Rentzel, IPNA, Basel University, Switzerland)

Table 6.1 Seasonal division of subsistence and economic activities in the Neolithic lacustrine village of Arbon-Bleiche 3

	Domestic animals						Wild animals												Cultivated plants					Collected plants									
	Slaughter			Other work			Hunting							Fishing																			
	Cattle	Sheep and goat	Pig	Herding	Milk	'Sheep shearing'	Red deer	Shed antler	Wild boar	Wild ducks	Pigeons	Bewicks swan	Common frog	Catfish	Red-eye	Pike	Shore shoaling fish	Whitefish	Sowing	Weeding	Harvesting	Crop processing	Flax processing	Berries	Apple, sloe, rose etc.	Nuts, acorns etc.	Vegetative plant parts, Mushrooms	Leaves/culms of 'grasses'	Cutting twigs	Felling trees	Leafy hay	Catkins	Bast
January	●	●	●	●			○		○			●										○	○						●	●		○	
February	●	●	●	●			○	○	○			●	●									○	○				○		●	○		●	
March	●	●	●	●		●	○	●	○			●	●			●			●			○	○				●		○			●	
April	○	○	○	●	●	●	○	○	○						●	●			●	●							●	○	○				●
May	○	○	○	●	●	●	○		○						●	○	●		○	●				●			●	●	○				●
June	○	○	○	●	●		○		●					●	○	○	●			○	○	○		●			●	●	○		●		○
July	○	○	○	●	●		○		●					●	○	○	●				●			●			○	●	○		●		
August	○	○	○	●	●		○		●		●			●	○	○	●				●			●			○	○	○		●		
September	○	○	○	●	●		○		●		●				○	○	●		○	●	○	●		●	●	●	○	○	○		○		
October	●	●	●	●	●		●		○	●	●				○	○	●		○	●		●	○		●	●	○	○	○				
November	●	●	●	●			●		○	●	●	●						●		○		○	○		○	●			●	●			
December	●	●	●	●			●		○	●		●						●				○	○		○				●	●			

Note: Solid dot (●) = intense activity; circle (○) = moderate activity.
Source: Data courtesy of Stefanie Jacomet, IPNA, Basel University.

Subsistence and Economy

Two of the main tasks of the entire Arbon-Bleiche 3 project were the palaeoenvironmental and palaeoeconomic (including subsistence strategies) reconstructions, which were achieved by remarkable tandem collaboration between archaeobotany and archaeozoology (Deschler-Erb and Marti-Grädel, 2004*a*, *b*; Hosch and Jacomet, 2004; Zibulski, 2004). Not only has it been possible to reconstruct the environmental aspects of the village and surroundings (e.g. the predominant tree species and woodland management), but also a detailed outlook of seasonal subsistence strategies, including crop cultivation, animal husbandry, hunting, fishing, and the various gathering activities (see Table 6.1).

Systematic distribution analysis of the archaeological material in each of the single houses has allowed archaeologists to ascertain the division of labour in the village between food and artefact production, and even possible connections between different houses (and/or households) (Doppler et al., 2011). Because of the large amount of wild animal remains in houses 1, 8, 20, and 24, it was possible to label them as 'hunters' houses'. Similarly, the large quantity of gathered plants (fruits, nuts, etc.) recovered from house 14 gave it the title of 'gatherers' house' (Jacomet et al., 2004). Thorough archaeozoological analyses have even been able to establish a difference in diet between people living in the landward part of the village and those occupying the lakeward quarters. In fact, more beef (C) and more fish caught close to the shore (A) were consumed in the landward houses, whereas people of the lakeward dwellings preferred pork (D) and open water fish (e.g. whitefish) (B) (see Fig. 6.9) (Deschler-Erb and Marti-Grädel, 2004*a*, *b*; Hüster-Plogmann, 1996, 2004).

Meat (about a 50:50 ratio wild to domestic animals) and fish were obviously not the only sources of food. Cultivated plants (mainly naked wheat, emmer, and barley) and collected plants and fruits (berries, nuts, bladder cherries, sloes, and apples, see Fig. 6.10) were also important (possibly even more important than meat) in the Arbon-Bleiche 3 inhabitants' diet (Jacomet et al., 2004). Food was eaten both raw and regularly cooked in pots, as crust residue analysis on pottery has confirmed. In fact, traces of cereal grains (naked wheat) and fruit seeds (e.g. bladder cherry, *Physalis akekengi*), as well as an entire fish fin (Fig. 6.11), were found encrusted in the interior of a few cooking pots. Microscopically recognizable meat residues were not found (Martínez Straumann, 2004), but traces of fat were chemically identified, proving that meat and dairy products were regularly cooked in those vessels (Spangenberg, 2004).

continues

Box 6.2 Continued

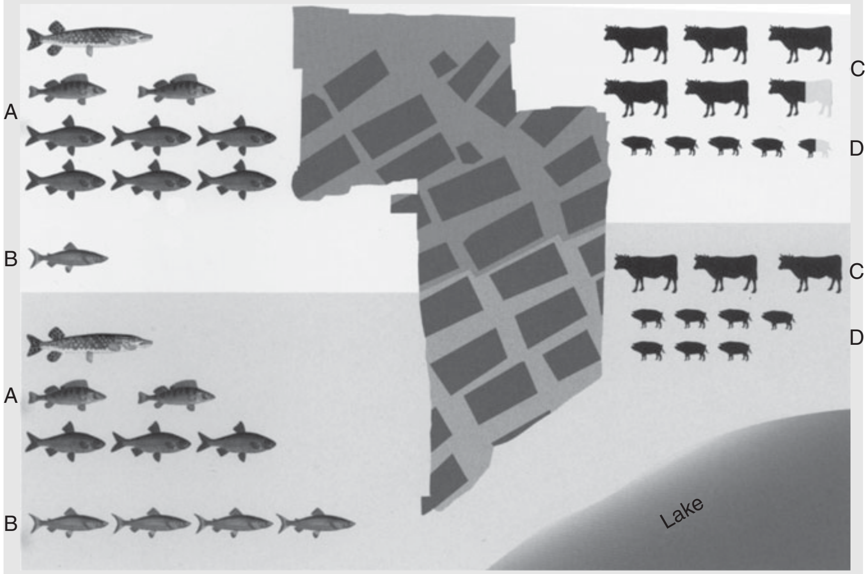


Fig. 6.9. Plan of the Arbon-Bleiche 3 Neolithic lake-dwelling, showing differences in animal husbandry and fishing activity within the village. People in the landward quarter ate more beef (C) and fish caught close to the shore (A); people in the lakeward quarter ate more pork (D) and fish caught in open water (B). (Courtesy of the Palafittes Association. *Graphic*: R. Buschor. *Data*: Heide Hüster-Plogmann, Jörg Schibler and Urs Leuzinger)

Fig. 6.10. Perfectly preserved half a wild apple, found at Arbon-Bleiche 3. (Courtesy of the Amt für Archäologie Thurgau, <www.archaeologie.tg.ch>)

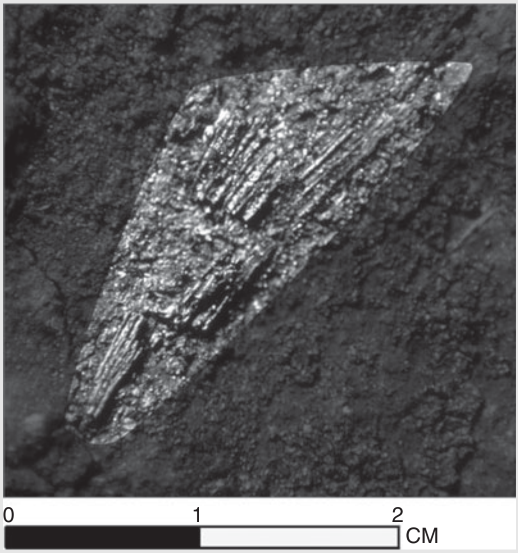


Fig. 6.11. An entire fish fin, found encrusted in the interior of a cooking pot at Arbon-Bleiche 3. (Courtesy of the Amt für Archäologie Thurgau, <www.archaeologie.tg.ch>)

Refuse and 'Toilets'

An important part of the Arbon-Bleiche 3 project was to identify the different types of coprolite found in various parts of the village. The identification of cattle dung turned out to be in some cases (e.g. on heavily trampled surfaces) problematic. Although microscopic analysis and thin-sections did manage to identify specific contents typical of cattle dung (Akeret and Rentzel, 2001), aDNA analysis failed to confirm the presence of animal DNA in it (Turgay and Schlumbaum, 2004) (see also 'Ancient DNA Preservation in Waterlogged Contexts', above). Despite the large amount of human faecal remains, the extension of the excavated area (note that the twenty-seven excavated houses were probably only one-third of the entire village) and the house architecture (on stilts) did not allow for the identification of the exact location of the possible 'toilets' and specific 'rubbish bins'. However, accumulations of plant and animal remains in particular spots under the house suggests the possible use of rubbish flaps located in the elevated house floor (see Fig. 7.24) (Leuzinger, 2000, 2001, 2002).

continues

Box 6.2 Continued

Hygiene

The presence of stagnating water in the village (also confirmed by insect analysis) and the quantity of faecal (human and animal) remains near the houses have triggered questions concerning the level of hygiene in the settlement and the health conditions of the inhabitants. Palaeoparasitological analysis on a number of human coprolites has identified the presence of various intestinal parasites, such as the fish tapeworm (*Diphyllobothrium* sp.), the giant kidney worm (*Dioctophyma* sp.), beef/pork tapeworm (*Tænia* sp.), and whipworm (*Trichuris* sp.) (see Fig. 6.12 a, b, c, d), suggesting that fish and meat were not properly cooked and the basic rules of hygiene (e.g. drinkable water, refuse management) were not followed (Bouchet et al., 2003; Le Bailly and Bouchet, 2004; Le Bailly et al., 2003, 2005, 2007).

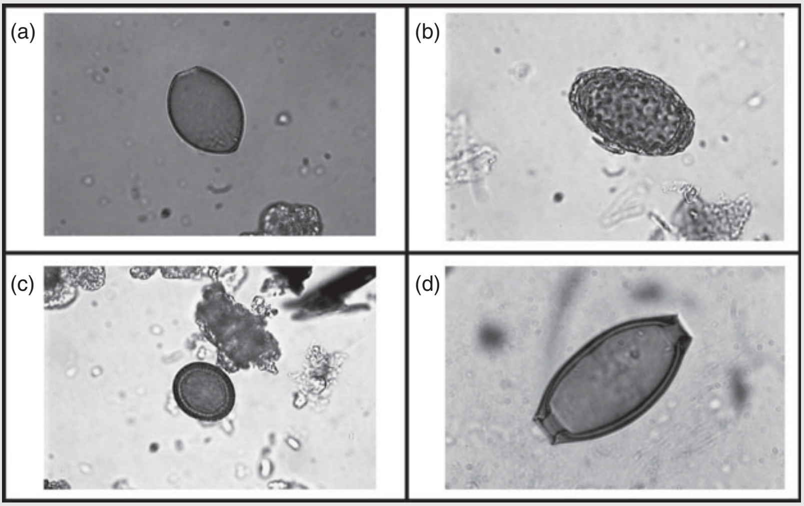


Fig. 6.12. a) Parasite eggs of the fish tapeworm (*Diphyllobothrium*); b) the giant kidney worm (*Dioctophyma*); c) the beef/pork tapeworm (*Tænia*); d) the whipworm (*Trichuris*). (*Photographs*: courtesy of Matthieu Le Bailly, UMR 6249 Chrono-Environment, Besançon, France)

Contact

A final aim of the Arbon-Bleiche 3 multidisciplinary research was to establish the extent to which the lacustrine village was connected to the 'external' world. Distributional patterns of material culture within the village have established long-distance trade links to present-day southern

Germany, Austria, the western Carpathian Basin, and northern Italy (e.g. the flints from Monti Lessini). Furthermore, the presence of specific botanical taxa (e.g. Swiss club-moss (*Selaginella helvetica*); and the Alpine speedwell (*Veronica alpina* L.)) also proved an inter- and intra-regional mobility, possibly in connection with seasonal (summer) transhumance activity. One of the most intriguing enigmas of the study was, however, the presence of the Boleráz-style pottery in various houses. Was the pottery imported from the western Carpathian Basin, or was it made locally? Petrographical, mineralogical, and chemical analysis of potsherds confirmed that the pottery was definitely made locally, but with both regional and Boleráz influence (De Capitani and Leuzinger, 1998; De Capitani et al., 2002). Because different types of temper (e.g. granite = local tradition; grog = Boleráz tradition) were used in a variety of interwoven ways, it is possible that 'immigrants' from the western Carpathian Basin were part of the village population, and they brought the ceramic knowhow with them when they came (Bonzon, 2004: 311).

Arbon-Bleiche 3 is a typical example of the great potential of multidisciplinary research in waterlogged archaeological contexts. The synergetic collaboration between the disciplines has confirmed and disproved old and new theories, and shed light on questions that would otherwise have remained unanswered. However, excellent preservation does not always mean positive results. The site has highlighted the importance of a thorough systematic sampling strategy, planned well before the excavation begins. It has become more and more evident that the availability of an enormous amount of unsystematically collected data may obscure rather than shed light upon crucial research issues.

CONCLUSION

As stressed in the introduction, multi-disciplinary research has become an essential part of archaeology. This is particularly true within waterlogged archaeological contexts, for their large quantity of well-preserved evidence triggers more and more questions. Throughout the chapter some of the most applied analytical methods within the various subdisciplines of archaeology have been discussed, highlighting their advantages as well as acknowledging their limitations. It has been seen, for instance, that despite their morphologically intact structure, waterlogged organic materials do not preserve

aDNA very well, especially concerning human and animal remains. It has been noted that archaeozoological studies may be limited to minerogenic deposits with a slightly high alkaline content, as acidic bogs do not facilitate bone preservation. It has also been seen that palaeoenvironmental reconstructions are no longer the result of a single-discipline work, but a symbiotic collaboration of many disciplines. For example, a change in vegetation has to be confirmed by palaeoclimatic variations, which themselves need support from geoarchaeological, malacological, and archaeoentomological analyses. Even the high precision of dendrochronology needs help from archaeoentomology, as, for instance, only bark-living beetles together with the absence of insects living on hardwood can suggest that wooden building materials obtained from a tree were used straight after the tree was felled (Lemdahl, 2004: 371). The remarkable intricacy of human relationships with the various ecosystems requires a multifaceted research approach. This synergetic effort, however, calls for more systematic and standardized sampling strategies in order to facilitate crucial comparative analyses between the various disciplines, which would otherwise not be possible.

7

True or False? Learning via Experiments

INTRODUCTION

Experimental archaeology has always played an important role in wetland archaeology. The remarkably well-preserved organic material artefacts found in waterlogged contexts have challenged archaeologists to go beyond the boundaries of simple conservation and display. We now want to find out how those objects were crafted, the technology used, their function, and most importantly we want to know more about the people who made them. Experimental archaeology is not only about reproducing artefacts, but also understanding the process of making them with the correct tools and materials, and applying the correct technology contemporaneous to the original objects (Kelterborn, 1990; Mathieu, 2002; Shimada, 2005). It is only by acquiring this knowledge that light will be shed on more complex issues concerning the socio-economic organization of the society, group, or community under scrutiny.

As eloquently argued by John Coles (1979), there are three levels of experiment: the lowest, when the artefacts are reproduced for purely aesthetic reasons without being concerned with the construction process; the second level, placing the emphasis on the process of production and manufacture; and the 'highest' level (level three), which is concerned with the presumptive (or definite) purpose(s) of the artefacts, their use, and manipulation. There might be even a fourth level, which goes beyond the simple functional testing and considers the society (in which the artefacts were produced) as a whole (hierarchical division, sociopolitical organization, economy, etc.).

Notwithstanding the level of experiment being dealt with, experimental archaeology will always need to borrow insight from other disciplines. This could be simply regarding technological aspects (how to carry out the experiment), or more delicate socio-interactive issues. A field of social sciences that is particularly close to experimental archaeological research is ethnography. A synergetic collaboration between archaeologists and local ethnic groups has become germane for a better and more holistic understanding of ancient material culture. A good example is the identification of unusual objects no

Fig. 7.1. Enigmatic object found at the Late Bronze Age lake-dwelling of Greifensee-Böschen, Lake Greifen, Switzerland. (*Photograph*: Martin Bachmann, courtesy of the Kantonsarchäologie Zürich, Switzerland)

longer in use today. Strong links to ancient tradition that have been perpetuated through generations (such as those of the First Nations and Native American people in North America, the various South American Indian communities, the Aborigines in Australia, or the Maori in New Zealand, to mention but a few) may be of great help in this case (Croes, 2010; Croes and Foster, 2003; Harris, 2000; Phillips et al., 2002).

No matter how hard the endeavour, though, there will always be objects that will remain unidentified (see Fig. 7.1). This is probably the reason why the development of the fourth level of experiment should be included in the archaeological process more often in the future. A particular attention to the society as a whole, as well as the single individual within it, will certainly facilitate our understanding of human agency, and perhaps those illogical actions hidden behind logical purposes will be better understood (Fig. 7.2).

The chapter discusses a number of experiments within the three (sometimes pushing the boundaries to the fourth) above-mentioned levels. In some cases (e.g. house reconstructions), a single experiment may include a series of other experiments (e.g. tool testing, labour requirements, raw material availability, forest management, building techniques, duration of the structure, and site formation processes), which themselves may belong to one or more of the three levels. It is indeed with this more holistic way of experimenting that the boundaries of our understanding may be pushed to the fourth level. Some experiments, on the other hand, do not (intentionally) go beyond level one. Yet again, they make people think (new ideas and elaborations will be produced), and by doing so, we are catapulted to level four automatically, and, who knows, some of us may be brave enough to go back to level two and start a

Fig. 7.2. Did all ancient artefacts have a specific function? (*Drawing*: Olenka Dmytryk)

new process of analysis over again. Important aspects of experimental archaeology are objectivity and perseverance. It is certainly not always about successful experiments: good results can sometimes be obtained from experiments that go wrong.

PRINCIPLES, PURPOSE, AND INTERPRETATIONS: WHAT, WHY, AND HOW

In over one and a half centuries, experimental archaeology has established the foundations of observing human behaviour by reconstructing and testing material culture found in archaeological sites. It has, however, become clear that simply appreciating the technological aspects of archaeological artefacts does not necessarily mean understanding people's behaviour and way of living. In addition to identifying and categorizing artefacts, it is crucial to question why and how those artefacts were produced in that specific way. The high variety of well-preserved waterlogged archaeological remains allows investigations into a multitude of people's patterns of activities, rather than focusing the attention on synchronically isolated events. A model-building concept of research is therefore much more suitable for a more holistic perception and understanding of ancient activities. In fact, what is seen as

archaeological evidence (even the smallest object) is the result of a myriad of actions whose traces are often lost forever. A good example is the heap of half-finished lathe-turned wooden bowls found at Feddersen Wierde, Germany (Haarnagel, 1977; Schmid, 2002). The well-preserved bowls show different stages of construction, which allows archaeologist to identify the type of tools used by the Feddersen Wierde craftsmen and, potentially, recreate the artefacts. Moreover, the presence of various workshops in the settlement facilitates comparative analysis of the different styles (of different craftsmen) within the village, shedding light not only on technological characteristics but also on the socio-economic aspects of the entire community. Whether real or imaginary, models should always be constructed on the basis of the surviving archaeological evidence. However, a simple reproduction is certainly not enough to understand them fully; well-structured tests should be performed in order to see their level of efficiency and understand the reason why they were originally created in that way. Full-scale reproductions (the same size as the original) can in this way be handled, used, manipulated and (if required) deliberately broken to test their limits—to push these limits is also very important. The use of an artefact may go beyond its conventional purpose. For instance, an axe can also be used as a spade or a knife, as much as an ornament can have a practical function (e.g. a tooth pendant used as a cutting implement). As ethnographic studies have shown, present-day conventionality does not always agree with that of the past, and vice versa. It is, however, understood that, whatever the purpose of the experiment, it is vital to ask coherent initial questions in order to obtain a final plausible interpretation.

Different experiments have different aims, which need to be clearly identified before the experiment is carried out. An object can, for instance, be reproduced for merely aesthetic reasons, for understanding technological attributes, or for shedding light on its function and relationship to its constructor. As briefly mentioned above, John Coles (1979: 36–40) has grouped this threefold orientation of archaeological experiments into three levels.

The lowest (as he calls it) is the simple reproduction (a copy) of an original artefact in order to display it (museums, private collections, etc.). As no further testing of the object is required, the material and technology employed to make the object is not important (e.g. the tools can be modern and the material slightly different). There have been incandescent debates as to whether this level can (or should) be regarded as proper experimental archaeology; yet visual effects are considered by many to be an important tool of analysis. Museums, for instance, are full of such objects, whose pedagogical value has been exploited largely to educate (young) people, giving them a full-scale perspective of past material culture, when, for some reason, the original object is not available (Schöbel, 1997, 2004*a*, 2005). Furthermore, the establishment of 'hands-on archaeology' areas in open-air museums gives people the possibility of handling some of these objects, allowing a further interaction with the

past (Leuzinger, 2004) (see also Ch. 9). Some scholars argue that in this way the first level of experiment may develop into the second level, or at least create new ideas for other, similar second-level experimental work.

The second level of experiment is linked to identification, testing processes, and the production techniques presumed to have been used in the past. The main purpose here is not only to reproduce artefacts, but also to manufacture them correctly, using the appropriate materials, tools, and technologies contemporaneous to the original objects. If, for example, one wants to understand the manufacturing process of a Neolithic tooth pendant, it would be totally useless to drill the hole with a steel bit attached to an electric drill. Instead, it would make much more sense to adopt flint or bone burins, available at the time the original object was crafted. However, an important variable that must be taken into account is the familiarity of the experimenter with the tools. It is possible that, because of their meticulous research, archaeologists reach a good level of knowledge of ancient tools, but at the same time they might not have the necessary skill to handle them. In fact, the skills of a professional carpenter are certainly much more developed than those of a university professor who has perhaps never handled a tool in her or his life, but knows everything about them. An ideal situation would be a craftsperson or carpenter specialized in ancient technology and familiar with ethnography. Ethnographic research can be extremely useful in experimental archaeology, as there are still a few ethnic groups that (either because they want to, or they have no choice) are using ancient technology. Their work would not only help archaeologists prepare the experiment, but it would possibly also shed light on the identification of the peculiar artefacts often found in archaeological assemblages (see below).

Ethnographic studies are also very much linked to the third level of experimental work, which is concerned with the function of the artefacts. Although there are some objects whose function can be understood and performance tested without necessarily following accurate manufacturing procedures (e.g. testing the carrying capacity of a dugout, which was reproduced without using ancient tools), the majority of them do require an accurate execution of level two of the experiment. Testing the function is also strictly connected with the operation itself and the environment (see above). For instance, the way one wields a metal axe varies significantly from how one uses a stone axe; not only do the angle and frequency change, but these (angle and frequency) are further modified and adjusted according to the material (wood species) upon which the axes are used (Coles, 1973, 1979; Pétrequin et al., 2006*b*). An important aspect that should always be considered in functional testing is repetition. A single experiment is usually not sufficient to prove its validity, for it may be the result of chance. Consistency in methodology is also a crucial element in the repetition of a series of tests. Not only should the same approach be used in every repetition, but also the various repetitions should be carried out or directed by the same person. For further confirmation of the

results, the series of tests can eventually be compared with other series, performed by other different experimenters.

Experiments in archaeology are carried out in different ways according to what we (archaeologists) try to prove and what we have available. Full-scale reproductions are, of course, preferred, but unfortunately not always possible, as they can be extremely time-consuming and/or expensive. Some types of experiments do allow scaled reproductions (e.g. boats, textiles, basketry, cordage, etc.), although they are sometimes difficult to interpret, since too many variables have to be calculated. There is also the possibility of conducting the experiments on paper, from a purely theoretical perspective. This method is used very seldom, because some aspects of the experimental process are virtually impossible to simulate.

Experimental archaeology can be extended to a further level, involving socio-economic aspects of the social group within which the material culture was created. For instance, is social hierarchical structure linked to technological development, or is it a single individual's influence that triggers the invention and/or drives the development of a specific technology? This possible fourth level of experiment goes beyond the empirical aspect of experimental archaeology, entering new research territories that involve the adoption of theoretical approaches borrowed from other social science disciplines (e.g. sociology, psychology, etc.) (Pingel, 2009).

Regardless of the level of the experiment, there are certain rules or points that should be respected if reliable results are required. These are, for instance, a thorough consideration of the archaeological evidence, a proper research background of the object being experimented with, and an adequate choice of materials, methodology, and technology. It is furthermore vital to produce a detailed recording of the experiment (so that it can be repeated by others) and set the specific aim in advance, being at the same time prepared for unexpected results (Rosenfeld, 2003). Finally, one should be as objective as possible, without being afraid of a negative outcome—a failure in proving one specific theory may be a success in confirming another.

Ethnographic Help

Waterlogged archaeological sites often preserve artefacts (in particular those made of organic materials) that archaeologists may not be familiar with. No matter how hard the endeavour (by means of experiments, literature reviews, etc.), there are always some objects whose function is extremely difficult to determine. Ethnographic research can in this case be of great help (Castañeda, 2009; Castañeda and Matthews, 2008; Colwell-Chanthaphonh and Ferguson, 2008; Edgeworth, 2006). Although primitive communities are not to be found living in complete isolation from the modern world and using only ancient

technology, part of their material culture may still be linked to the past. Some of their artefacts may in fact share some similarities with unknown archaeological objects, hence facilitating a possible identification of archaeological material. Although, as pointed out in the introduction, some objects are, and probably will remain, unidentifiable, there are numerous cases where ethnographic work has shed light on a number of mysterious artefacts and structures. Two succinct examples are the Arbon-Bleiche 3 'boomerang', and the trapezoidal structure of Steinhausen-Chollerpark (Lake Zug), both found in prehistoric lacustrine settlements of the Circum-Alpine region.

Although the Neolithic boomerang from Arbon-Bleiche 3 (Fig. 7.3) is not the first boomerang-shaped specimen found in Europe (see e.g. Magdeburg-Neustadt, Germany; Velsen, the Netherlands; Brabandsee, Denmark; and Oblazowa in Poland), it is unique in the Alpine foreland. Its shape does resemble that of an Australian Aborigine boomerang, but whether or not it would return to the thrower could only be tested via experiment. An exact replica was therefore constructed and thrown in a systematic manner a few times (also in the night with low-intensity sparklers appositely fitted on it to trace the trajectory, see Fig. 7.4). The artefact flew between 35 and 50 metres, but alas, did not return. The object was, however, identified as a hunting implement, for in Australia, too, there are such boomerangs with

Fig. 7.3. Boomerang-like artefact, found at the Neolithic lacustrine settlement of Arbon-Bleiche 3, Lake Constance, Switzerland. (*Photograph*: courtesy of the Amt für Archäologie Thurgau, <www.archaeologie.tg.ch>)

Fig. 7.4. Testing a reconstruction of the boomerang-like artefact from Arbon-Bleiche 3. The exact trajectory has been traced by applying low-intensity sparklers on the implement and throwing it in the dark. (*Photograph*: courtesy of the Amt für Archäologie Thurgau, <www.archaeologie.tg.ch>)

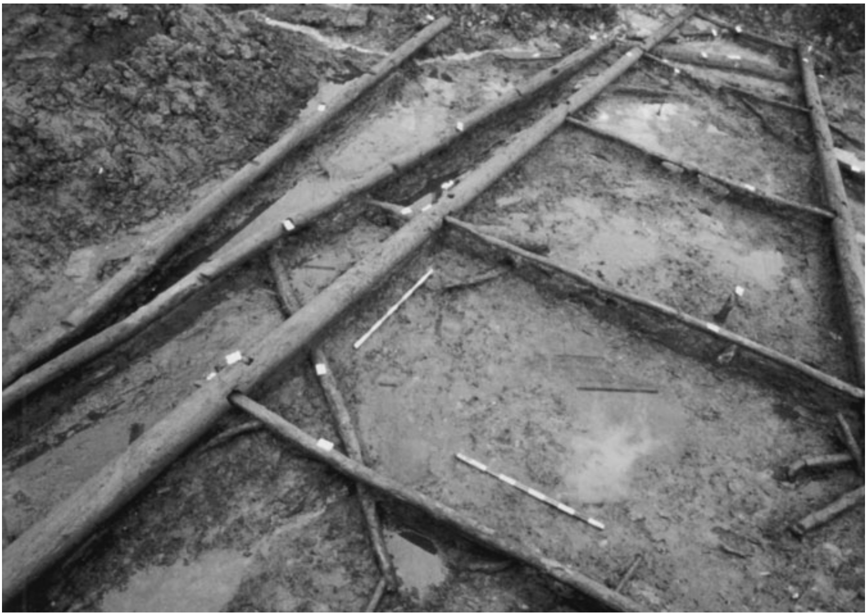


Fig. 7.5. Trapezoidal structure (no. 3) found at Steinhausen-Chollerpark, Lake Zug, Switzerland. (Courtesy of Stefan Hochuli, Kantonsarchäologie Zug, Switzerland)

non-returning rectilinear trajectory (Bauer and Leuzinger, 2004; Leuzinger, 2002; Stehrenberger, 1997).

Much larger, but equally mysterious archaeological evidence came to light at Steinhausen-Chollerpark (Lake Zug), in 1999. The remains consisted of five (two entire and three partial) wooden structures of trapezoidal shape (Fig. 7.5), measuring up to 14 metres in length and 2 to 7 metres in width, and dating to between the fifteenth and twelfth centuries cal BC (Eberschweiler, 2004; Hochuli and Röder, 2001).

Since such structures had never previously been found in any lake-dwelling settlement in the Circum-Alpine region, a lot of speculative ideas were initially

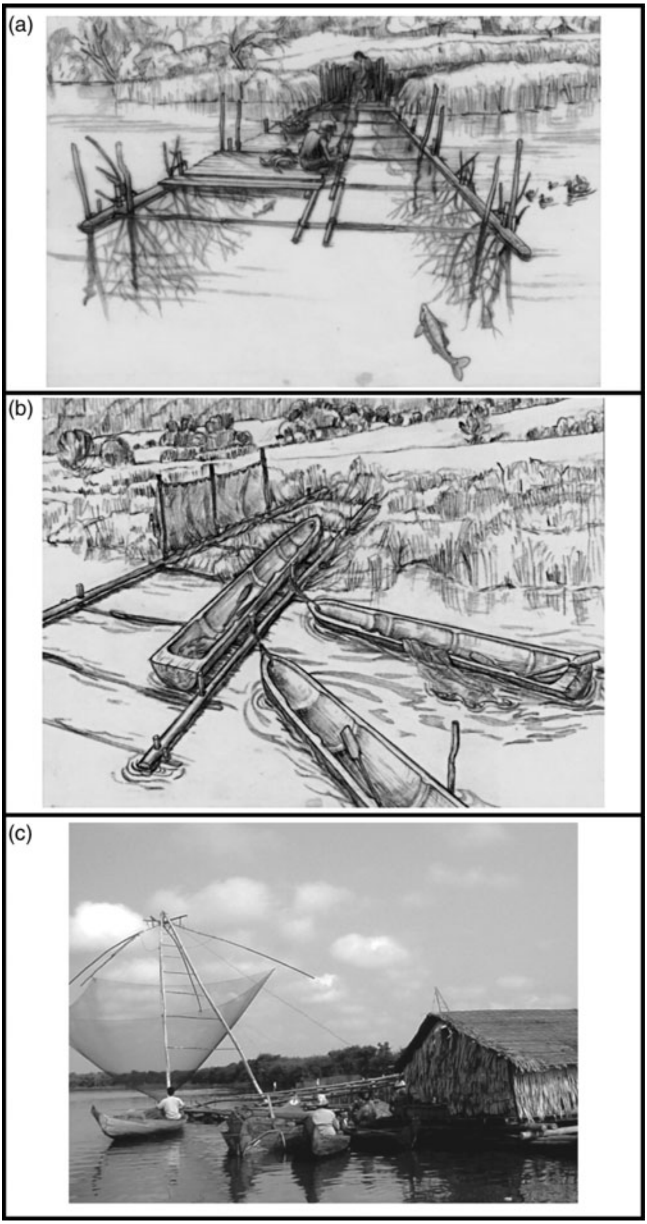


Fig. 7.6. Presumed functions of the trapezoidal structures of Steinhausen-Chollerpark, Lake Zug, Switzerland: a) semi-permanent structures to attach fish-traps along the lake shore; b) landing places for dugouts; c) frames for holding fishing nets on Lake Tonle Sap, Cambodia. (*Drawings* (a) and (b): Eva Kläui. courtesy of Kantonsarchäologie Zug. *Photograph* (c): courtesy of the Cambodian Research Centre for Development, Phnom Penh, Kingdom of Cambodia)

formulated, until a more thorough ethnographic study was carried out. Clues as to how the trapezoidal wooden structures may have functioned were found in various places. They could have been used as semi-permanent structures to attach fish-traps along the lake shore (Fig. 7.6a), or as landing places for dugouts (Fig. 7.6b) similar to those on the Northwest Coast of North America (Croes, 1995: 230), or even as particular frames for holding fishing nets, as those encountered on Lake Tonle Sap in Cambodia (Fig. 7.6c) (Eberschweiler, 2004: 101).

These are but two examples showing that the synergetic effort between ethnographic research and experimental archaeology can often provide plausible answers to archaeological conundrums. It is up to the persevering archaeologist (and a bit of luck) to find them.

FROM ORIGINALS TO RECONSTRUCTIONS: BRIDGING THE GAP

The main advantage that experimental archaeologists have when working with waterlogged artefacts made of organic material is their remarkable state of preservation. This allows not only their full replication, but also a detailed study of the processes involved in making them. Wooden artefacts, for instance, still retain the evidence of cut marks, through which tools (e.g. adzes, axes, knives, etc.) can be identified. These tools can subsequently be replicated and tested to see their efficiency and performance. Large remains of house structures show, for instance, the different architectural characteristics, allowing remarkably detailed full-scale reconstructions. The movement of people and goods is confirmed by the variety of means of transport; from simple travois to more sophisticated wheeled vehicles on land, and a large range of watercraft on rivers, lakes, and seas. Notions of means of transport too are constantly challenged, revealing a much larger range of social interaction, trade, and exchange than ever expected. Full-scale houses, trackways, and boat reconstructions have, in particular, highlighted the need for a better understanding of raw material procurement, with a special emphasis placed upon wood. Along with other disciplines such as dendrochronology and archaeobotany (see Ch. 6), experimental archaeology has embarked on a new challenge to shed light on woodland management. Lack of building material caused by the overexploitation of natural resources, deforestation, and erosion are not just present-day problems but were also very real issues in the past. Wooden structures, tool marks, and different choices of wood species have revealed a careful planning of woodland management, which in some cases dates back more than 5000 years (Pétrequin, 1995). It is a careful

consideration of all these factors that shows how the reconstruction of an experimental house can, for instance, trigger new research orientations beyond the initial aim of the experiment, thus entering a more holistic consideration of ancient artefacts and their creators.

Wood

Wood is by far the most common material found in waterlogged archaeological contexts. Not all artefacts or structures, however, are made of the same wood species. The choice of a particular kind of wood depends not only on the availability of the wood, but, most importantly, on its performance. Some types of wood are harder, lighter, or even more aesthetically attractive than others, and this obviously influences people's choice. Soft wood is, for instance, unsuitable for axe or adze handles, as much as it is counterproductive to use hard and fibrous wood for a sophisticated wooden sculpture. Even houses were constructed with different species of wood (see below). The consistency of wood also influences the choice of tools to work it. It seems obvious, for instance, that metal axes were more efficient at felling trees than stone ones. However, flint and/or bone or antler implements may be more suitable than metal (e.g. copper and bronze) for carving and sculpturing.

Woodworking

There is no better way to understand ancient woodworking techniques than learning them by experiment. It may seem basic and straightforward, but felling a tree is one of the most demanding and time-consuming tasks. It is of course understood that the difficulty and the amount of time needed to fell a tree depends on the species, diameter, and, most importantly, the archaeological period. For instance, stone axes are usually less sharp than bronze ones, therefore needing more time for the felling process. The technique used to handle the cutting implements also varies considerably. Hafted stone axes are best used by a controlled flurry of blows made from the elbow, rather than a larger, wider swing (O'Sullivan, 1996). Large (in diameter) trees were felled using the splitting method, whereby strips of bark, sapwood, and heartwood are chopped out, creating a large notch, before starting a shallow-angle cutting process (Fig. 7.7), which reduces the tree diameter gradually, until the weight of the tree causes it to fall automatically (Monnier et al., 1991; Pétrequin and Pétrequin, 1993).

Metal axes, on the other hand, produce a less wide notch, as they are sharper and the cutting angle can be steeper. The chips detached by metal axes are long and clean, as opposed to those produced by stone axes, which are rather short

Fig. 7.7. Tree felling by stone axe (with details of a shallow-angle blow). (*Photograph*: courtesy of Pierre Pétrequin, Laboratoire de Chrono-écologie, CNRS, Besançon, France)

and smashed. As pointed out earlier, the tree species also influences the final result. For example, birch, hazel, and alder are quite easy to cut with both metal and stone axes, although the latter may have some difficulty with older and more fibrous birchwood. An important woodworking task is the creation of planks by splitting logs, using wedges and wooden mallets. Again, different kinds of wood split in different ways. Green (not dry) birchwood is quite difficult to split, whereas oak and ash logs are split quite easily. On the other hand, once the wood (especially oak) is seasoned, the splitting is much more difficult. This suggests that, at least in Europe's Neolithic and Bronze Age, oak logs were split into planks when still green (Coles and Coles, 1986).

Cut mark analyses on modern wood help identify ancient woodworking techniques. For instance, not only do stone and metal axes and adzes leave different traces on the wood, but each axe/adze has its own signature, making it possible to identify the number of different axes/adzes used in a specific construction (O'Sullivan, 1990, 1995, 1996). Cut mark analysis has a long research history, dating back to the nineteenth century when the method was even used for chronology purposes. In fact, with a series of systematic experiments on modern wood, Heydeck (1889, 1909: 194) was able to identify different cut marks on archaeological wood produced by different types of axes (stone, bronze, and iron). This allowed him to distinguish between Neolithic (Stone Age), Bronze Age, and Iron Age pile-dwellings in East Prussia.

Being familiar with all the various aspects of woodworking techniques is crucial, if one wants to embark on more demanding experiments, such as the reconstruction of wooden houses, trackways, and watercraft.

Reconstructing Ancient Wooden Houses

Remains of superstructures of wooden houses are not often preserved, and what is left for the archaeologists to work on is sometimes very limited. As a result, bridging the gap between the archaeological remains and the actual complete house is an arduous task. This task is made easier in waterlogged sites where in some cases even the smallest architectural detail of a wooden house is preserved. It was this remarkable archaeological evidence combined with ethnographic studies that first inspired archaeologists to build full-scale reconstructions of ancient wooden houses. Pioneering work started in southern Scandinavia, and more precisely in Denmark, where Hansen (1961, 1962), reconstructed a third millennium cal BC house (based on the excavation at Troldebjerg) at Allerslev, between 1956 and 1958. The solid foundations of experimental work in house reconstruction in Denmark continued throughout the 1970s and 1980s, with the establishment of the Historisk-Archaeologisk Forsogscenter (the Historic Archaeological Research Centre) at Lejre, where a number of house-building and house-destroying experiments (see below) were carried out (Hansen, 1977). The centre has expanded considerably since, and is still very active today, hosting a large number of experiments in a variety of fields (Hurcombe, 2008; Rasmussen and Grønnow, 1999). Thanks to the successful pioneering work of Danish archaeologists, experimental reconstructions of ancient houses increased significantly in various parts of Europe, and a number of experimental centres (e.g. the Buster Ancient Farm, West Stow and Glastonbury Peat Moors Centre in the United Kingdom, the Pfahlbaumuseum in Germany, and the Biskupin Museum in Poland, to mention but a few—see also Ch. 9) (Coles and Coles, 1989; Piotrowski, 1998; Reynolds, 1976, 1979, 1999; Schöbel, 2002, 2003*b*; Zajaczkowski, 1994), have been developed in the past few decades.

Despite the large number of house reconstructions and the establishment of various open-air museums displaying a variety of full-size reproductions, only a small number of such experiments have gone beyond level one (see above). The majority of them have in fact been built to please the eye and stimulate the imagination. Constructing a full-size dwelling following strict rules dictated by archaeological evidence is a very challenging task. Along with other examples, such as the houses of the Lejre Centre in Denmark and the reproduction the Hornstaad-Hörnle and Arbon-Bleiche 3 Neolithic houses at the Pfahlbaumuseum in Germany, one of the most complete and meticulously carried-out experiments is the reconstruction of two Neolithic pile-dwellings at Chalain, France (see Box 7.1).

Box 7.1 Pile-Dwelling Reconstructions on Lake Chalain

Between 1988 and 1989, the Centre de Recherches Archaéologiques de la Vallée de l'Ain, under the direction of Pierre and Anne-Marie Pétrequin, carried out the reconstruction of two Neolithic (*c.*3000 BC) pile-dwellings (see Fig. 7.8), similar to those excavated on the western shores of Lake Chalain, France (also the location of the experiment).

Fig. 7.8. The two experimental pile-dwellings, reconstructed on Lake Chalain, France. (*Photograph*: courtesy of Pierre Pétrequin, Laboratoire de Chrono-écologie, CNRS, Besançon, France)

The rules of the experiment were clearly set from the beginning: to reconstruct the houses by rigorously combining archaeological evidence with ethnographic studies (Petréquin and Petréquin, 1984, 1988; Pétrequin, 1997), and the technology employed had to be strictly linked to the Neolithic period. The experiment began in winter 1987–8, when the team started to fell the trees for the building, cut the reed for the roofing, and collect clay for daubing the house floor and walls. The preparation of the building material (cutting, splitting, shaping the piles, trimming the reeds, prepare sails (uprights) and rods (horizontals) for the wattle walls, and the various cordage) started in the late winter, but the house construction did not begin until late spring. The chronological order of the preparation as well as the building activity followed a precise seasonal planning that coincided with the characteristic environmental aspects of the area. For instance, the cutting of the

reeds for roofing has to take place in the first part of the winter, as earlier (autumn) reeds are not fully formed, and later (spring) they begin to degrade as new ones emerge. Summer, on the other hand, is the best season for building, since the lake water level is usually lower and the shores slightly drier, enabling people to move around more easily on site.

The Construction

The size of the two houses was the same (about 8 × 4 metres), but one house had double supporting piles (for the floor), and the other only single piles. The walls were also different: one house had only wooden plank walls, whereas the

Fig. 7.9. First stage of construction of one of the two experimental pile-dwellings of Chalain (*Photograph*: courtesy of Pierre Pétrequin, Laboratoire de Chrono-écologie, CNRS, Besançon, France)

continues

Box 7.1 Continued

other had a mixture of planks, reeds, and wattle-and-daubed walls. Both houses had thatched roofs. The first construction operation was to drive the supporting piles (for floor and roof) into the ground (see below for the various techniques), then floor and roof cross-beams were put in place (Fig. 7.9), along with the main structure of the roof (king posts, tie-beams, ridge, and rafters), and finally the surface of the floor. Wattling, daubing, and planking the wall preceded the thatching of the roof because light was needed for working inside. The daubing and plastering of walls and floors were the final tasks.

Time Needed and Materials Used

The duration of the various construction operations and the materials used were meticulously calculated for one of the two houses (the house with double-supporting piles). The preparation (tool-making, cutting, splitting, etc.), required 2738 hours; for transport (from the original source of the material) 190 hours; and the assemblage 681 hours. The total was 3609 hours, which roughly correspond to 452 days of work (at 8 hours per person per day) (for a detailed description see Monnier et al., 1991: 69–70). It has to be pointed out, however, that a group of skilled Neolithic carpenters, who were accustomed to this kind of work, may have needed much less time, especially for the tree-felling operation (see above).

Performance

The two houses were tested for some years; they were inhabited by volunteers (mainly students excavating the nearby archaeological sites—even I had the honour of sleeping in one of the houses for a few days in the summer 1997) for a couple of months per year, in both winter and summer. Various activities were carried out inside and outside the houses, such as cooking, food preparation, wood chopping, and other various daily tasks. Living conditions inside the house, especially working and resting space in relation to the fireplace, were also tested (see below). In addition to anthropogenic stress, the houses had to withstand natural calamities such as torrential rain, snow, high lake water levels, and stormy winds. The copious precipitation of the area, the inundations of winter 1988–9, the 90 cm of snow in December 1990, and the 120 km/h wind registered in winter 1990–1 have all pushed the two experimental houses to the limit. However, apart from a few necessary repairs, the two dwellings passed all the tests brilliantly, and continued their experimental tasks for many more years (both houses proved to be safely habitable for 11–12 years—Pierre Pétrequin, pers. comm. 2010), until they collapsed (one in 2002, and the other in 2009—see Fig. 7.10). The remains of the houses have been left in place, and will be studied in the future to shed light on the various aspects of site formation processes (see below).

Fig. 7.10. One of the experimental pile-dwellings of Chalain in a tilted position before collapsing in 2009. (*Photograph*: courtesy of Pierre Pétrequin, Laboratoire de Chrono-écologie, CNRS, Besançon, France)

Two similar house reconstructions have also been carried out at the Pfahlbaumuseum in Unteruhldingen, Lake Constance, Germany. The first house (based on the archaeological evidence of the Hornstaad-Hörnle 1A pile-dwelling) was built in 1996, whereas the second one (house 23 of Arbon-Bleiche 3 lake-dwelling settlement) in 1998 (Fig. 7.11) (Krauss et al., 1999; Schöbel, 1999).

Contrary to Chalain though, the two houses were not constructed using traditional Neolithic tools. However, size, material, and architectural techniques were reproduced as found in the original excavations (Jacomet et al., 2004; Leuzinger, 2000) (see also Box 4.1). These two houses have also been exposed to the inclemency of the lake, as is shown by the severe 1999 transgression (5.65 metres above the normal lake water level), which destroyed the plastered floor and part of the daubed walls of the Hornstaad-Hörnle house, as well as damaging that of the Arbon-Bleiche 3 house (see Fig. 7.12) (Schöbel, 1999). Despite the damage, the two houses are still standing.

Driving Wooden Piles into the Ground

The relative difficulty of driving wooden piles into the semi-dry or inundated lake marl has always been a topic of great debate. There have been a number of experiments on various types of lacustrine sediments in the past three decades, all confirming the apparently easy and relatively fast process. Although possibly dry on top (the first 10–30 cm), lake marl sediments found in various glacial and morainic lakes are often in a liquid state, retaining thixotropic characteristics similar to that of quicksand. These types of sediments are relatively solid until the vibrations of a penetrating object 'liquefies' them, thus facilitating the penetration of the object itself. Once the vibrations stop, the sediments become

Fig. 7.11. The two experimental houses at the Pfahlbaumuseum, Unteruhldingen, Germany. Left: the Hornstaad-Hörnle 1A pile-dwelling; right: the Arbon-Bleiche 3 pile-dwelling. (*Photograph*: courtesy of Urs Leuzinger)

Fig. 7.12. Record high water level of Lake Constance in May 1999, inundating the Arbon-Bleiche 3 house reconstruction. (*Photograph*: courtesy of Gunter Schöbel, Pfahbaumuseum, Unteruhldingen, Germany)

stable again. It has been calculated that once the dry surface is removed or wetted with additional water, the entire process of driving a wooden pile 2–3 metres into the lake marl takes no more than ten minutes (Monnier et al., 1991). With particularly soft and inundated sediments, such as those found in the eastern Baltic Sea region, the process can be even faster (Menotti and Pranckenaite, 2008). There are various methods of driving wooden piles into the ground, although the most common one is the rotate-lift-and-drop technique, standing on an elevated platform or structure (Fig. 7.13a). This was the technique mainly used in the lake-dwelling tradition of the Circum-Alpine region (Neolithic and Bronze Age). In later periods (especially Roman times), traces of archaeological piles (belonging to bridges) show the development of new methods, such as the rotation technique, whereby a pile is twisted into the

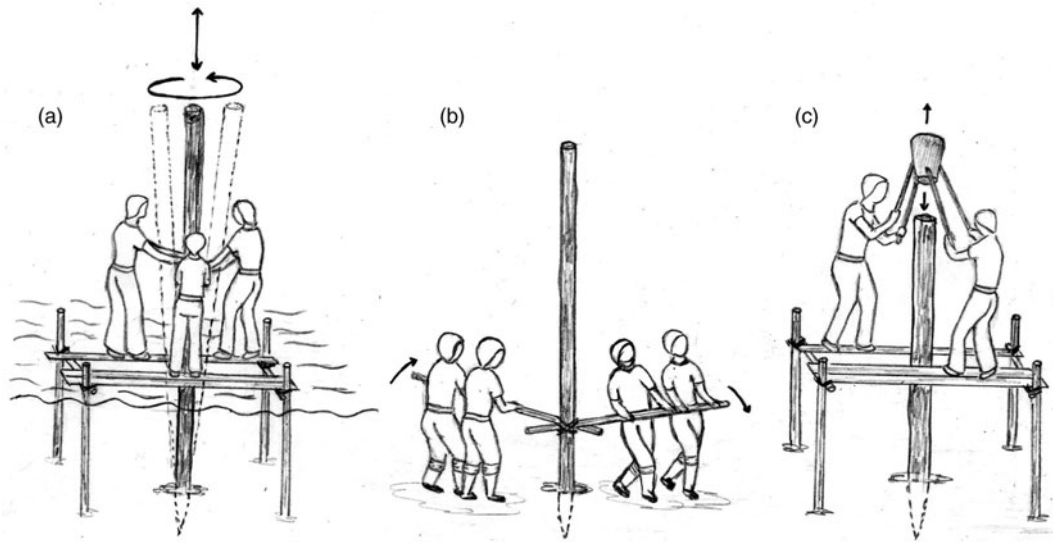


Fig. 7.13. Three techniques of driving wooden piles into the ground/lake marl: a) the rotate-lift-and-drop technique; b) the rotation technique; c) the wooden mallet technique. (*Drawings*: Olenka Dmytryk)

ground with the help of attached levers (Fig. 7.13b), and the use of a wooden mallet held by two people (Fig. 7.13c) (Pillonel, 2007*a*, *b*, 2009).

On the other hand, driving wooden piles into peat sediments is a much harder task. Even with the help of an initially excavated posthole, the piles cannot usually be driven into the peat more than 1 metre. It is therefore not surprising if the majority of houses found in peatbog environments (or shrinking lakes), were built directly on the ground (Schlichtherle, 1997*a*, 2002, 2004; Schlichtherle and Strobel, 1999).

Communication Networks

Trackways

The vast majority of experimental trackways have been built for purely aesthetic reasons, sometime as integrated parts of open-air museums. One of the best examples is the short stretch of the XLII (Ip) trackway at Wittemoor, Lower Saxony, Germany (with the characteristic wooden figures), reconstructed near the Pfahlbaumuseum, Lake Constance (Schöbel, 2006*a*: 33). Those trackways reconstructed for real experimental purposes (e.g. the 10-metre long part of the Sweet Track) (Coles and Orme, 1984*a*), have mainly aimed at testing the various construction techniques rather than their function and efficiency. The most often reproduced trackway is the hurdle type, whereby horizontal rods (usually ranging from 15 to 25 mm) are woven through vertical rods ('sails') to produce fence-like panels. These panels are used not only for trackways, but also for fences or house walls, and their size depends upon the skills of the hurdle makers and the availability of the material used. A series of experiments carried out in the Somerset Levels in the 1970s have revealed interesting results concerning ancient construction techniques, tools used, and procurement of raw material (the rods). It was, for instance, shown that the ancient hurdle makers' skills were initially underestimated, for the process of making them proved much faster than previously thought. Drawn-felling, related to coppicing in a woodland management context, was also shown to be less easy and efficient as it might have seemed. Finally, it was realized that some construction problems that occurred during the experiments (e.g. the rod twisting at some specific points) were also identifiable in the archaeological remains (e.g. the presence of double rods in some parts of the Walton Heath hurdle trackway) (Coles and Coles, 1986: 106; Coles and Orme, 1980).

Transport

Water Transport

Replicas and experimental reconstructions of watercraft have been a topic of great interest since the late nineteenth century. The fascination began in 1893,

when the replica of a Viking ship, the *Gokstad*, sailed across the Atlantic (from Norway to New York) in twenty-seven days, proving that such voyages had been possible even before Columbus (Mckee, 1974). Since then, a number of such experiments (with, of course, different goals) have been carried out. From daring sea voyages, such as the balsa raft *Kon-Tiki*'s Pacific crossing (from Peru to Raroia in Polynesia) in the 1940s (to prove that Polynesia could have been colonized from South America) (Heyerdahl, 1950); or, the more recent (unsuccessful) attempt to cross the Atlantic by a reed boat, the *Abora III*, in 2007 (Görlitz, 2008, 2010), to less spectacular, but by no means less important, half-scale models of the Ferriby I, Graveney, and Sutton Hoo boats (Gifford and Gifford, 2004).

The number of experiments linked to boat replicas is countless, each of them aiming at proving or disproving theories or assumptions hidden in the archaeological remains, which the remains alone could not elucidate. It was, for instance, during the reconstruction of the Gallo-Roman boat of Bevaix that its origins in northern European Bronze Age vessels were recognized (Arnold, 2004, 2009). Or similarly, only meticulous testing of the *Tilia Alsie* (a full-scale replica of the Iron Age, *c*.350 cal BC, Hjortspring boat) revealed the possibility of it having been an agile and effective warship (Kaul, 2004). Boat replicas can be either second- or third-level experiments (see above), but even if they are first-level, they are good examples of how an experiment can easily be upgraded to a higher level of analysis.

Dugouts are not only the oldest archaeological evidence of watercraft (see the Pesse canoe), but possibly also the most replicated. One of the most

Fig. 7.14. Theodore de Bry's sixteenth-century drawing of the logboat-making process used by the Native American Indians of Virginia. (de Bry, 1590–1634: plate XII)

fascinating aspects of dugout building is how very large trees were felled and the trunks hollowed to create canoes, using only simple stone implements. The ingenious method with extremely large trees (over 1 metre in diameter) was first recorded by Thomas Harriot in the sixteenth century. Harriot (1588) described how the Native American Indians of Virginia skilfully burnt the bole of the trees just above the roots to fell them. The log was then hollowed following the same method (see Fig. 7.14).

The number of experiments carried out in the past three decades or so have proved that logboats can be constructed in many ways: from burning techniques to the use of cutting tools made of stone, metal, and even bone (Christensen, 1990). Time of construction and technology naturally varied according to the

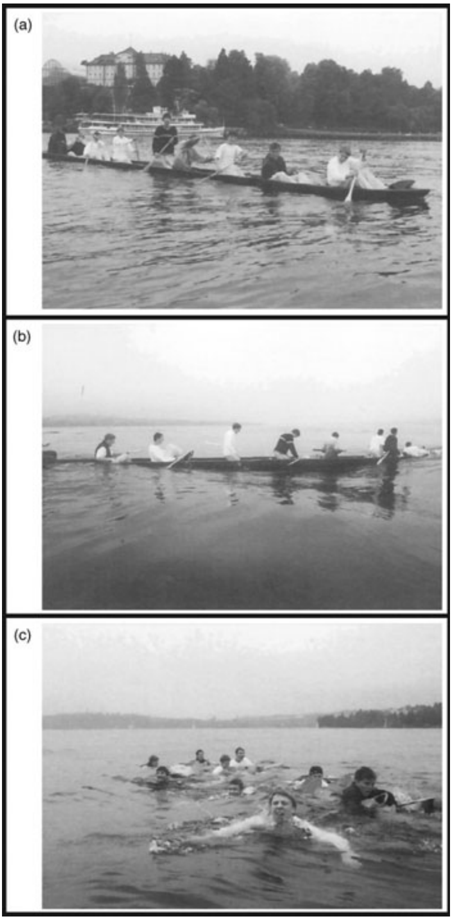


Fig. 7.15. Testing a Late Bronze Age dugout replica on Lake Constance: a). (The boat sunk after being hit by a large wave—b) and c). (*Photographs*: courtesy of Gunter Schöbel, Pfahbaumuseum, Unteruhldingen, Germany)

period and the skills of the carpenters. In recent years, the attention of logboat experiments has been focused on their performance. Amongst the large number of experiments one of the most complete (from tree felling to performance) is the dugout of the Pfahlbaumuseum in Unteruhldingen. The 13.40-metre long and 70-cm wide oak dugout (replica of a Late Bronze Age dugout found at Roseninsel on Lake Starnberg, Germany) (Beer and Schmid, 1997; Schmid, 1995) was built not to test ancient building techniques but mainly for its performance. The dugout was successfully launched in June 2000, and showed a staggering carrying capacity of ten people (or 800–900 kg). But, would such a boat be suitable for longer and faster journeys? To prove it, eight boys (aged 14 to 18) took the dugout for a ride to a nearby island, at a speed of about 5 km/h. The island was easily reached, but on the way back, a 'killer' wave, produced by a large ferryboat, hit *Fiana* (the dugout), and, alas, she sank (see Fig. 7.15) (Schöbel, 2001: 103). Of course, powerful motorboats would probably have not been around in the Bronze Age, but the experiment has revealed important aspects concerning logboat carrying capacities linked to weather conditions (e.g. stormy winds), during relatively long journeys.

Land Transport

The majority of experimental work concerning land transport (e.g. wooden wheels, axels, carts, and travois) does not go beyond the first level of experiment: aesthetic display (Schöbel, 2003*a*: 25). There have, however, been some attempts to test the performance of some systematically reproduced carts and travois. For instance, following the discovery of a Neolithic (3709–3707 BC) V-shaped wooden structure (interpreted as a wheeled travois) at Reute-Schorrenried (Lake Feder) (Schlichtherle, 2006*a*), a full-scale replica was created. The reconstruction strictly reflects the archaeological evidence, but its performance has, unfortunately, never been tested systematically. On the other hand, the carefully reproduced replica of the 5000-year-old intact travois found at Chalain 19 (see Fig. 7.16) (Pétrequin et al., 2006*c*) was systematically tested using traction animals (see Fig. 7.17) in 2007. Despite the fact that the animals (two cows) were not familiar with the travois, the experiment proved that, because of its strength and manoeuvrability, it could easily have been used to transport medium to heavy loads.

Basketry, Cordage, and Textiles

The large amount of waterlogged archaeological evidence concerning basketry, cordage, and textiles has triggered a great interest in reproducing and testing a variety of artefacts. It has already been seen how the works of Dale Croes and Katryn Bernick have contributed to highlight the importance of basketry along the Northwest Coast of North America, and how joint efforts between archaeologists and local communities is crucial for a more holistic

Fig. 7.16. The travois of Chalain 19 during excavation. (*Photograph*: courtesy of Pierre Pétrequin, Laboratoire de Chrono-écologie, CNRS, Besançon, France)

understanding of material culture (see Ch. 2, under 'North America', and Ch. 4, under 'Basketry and Cordage'). In his seminal work on basketry studies, Croes (1995, 1999) has often included experimental archaeology, stressing the importance of a systematic and close collaboration with local Native American communities during the replication of and experimentation with ancient artefacts. Part of his research has also emphasized the importance of using

Fig. 7.17. The full-size reconstruction of the Chalain 19 travois being tested with two traction animals. (*Photograph*: F. Menotti)

Fig. 7.18. Replicating a tule mat at Hoko River, Olympic Peninsula, Washington State, United States. (*Photograph*: courtesy of Dale Croes, Washington State University)

the right material with specific types of basketry. With the help of a local Native American basket weaver, he has, for instance, been able to show that sweet grass sedge (*Scirpus americanus*) is much more suitable than cedar bark for making diamond-plaited soft bags (this is also confirmed by cellular analysis) (Croes et al., 2009: 151–2). Tools for working basketry were also tested. For example, a replica of a mat creaser found at Hoko River was tested during the making of a large tule mat (see Fig. 7.18) (Croes, 1995: 176, 1999: 64).

Experiments on basketry, cordage, and textiles have pushed the boundaries of experimental archaeological research beyond technical aspects. Not only is it now important to understand the practical use (or choice) of raw material (Médard, 2005), or how it is prepared and worked to improve its properties (e.g. wool fulling and dying) (Frei et al., 2010; Paardekooper, 2005), but it is also crucial to explore new concepts and to develop new research approaches. It is also vital that the experiment discusses the various ways of perceiving information. For instance, plant collection, seasonality, and group organization are all interwoven in the final product, which itself reveals how people interact with the surrounding environment, choose specific items, and integrate them into the *chaînes opératoires*. With her project, 'Organics from Inorganics', Hurcombe (2007*a*, *b*, *c*, 2008) eloquently shows how clay impressions, as by-products of manufacture, can be read as conscious acts. The skeuomorphic impressions left by a mat, on which the pottery was worked, reflects the importance of the mat

itself, and the connection/relation between the two objects. The impression is therefore 'a conscious act, where notions of permanence and transience are played out in crystallised concepts of materiality' (Hurcombe, 2008: 107). Harris (2008) has taken the interaction of people with artefacts a step further. By testing different reactions to the sound, texture, and smell of different cloth types, she wonders if different perceptions can be spotted in the archaeological record, making it possible to identify shifts in the materiality of the cloth, alongside a diachronic change in technology through time.

The great variety of basketry, cordage, and textiles, and their extremely close relationship with people, allows a remarkable diversity of experimental approaches, which facilitate a more holistic understanding of human actions in a wider social context.

Bones, Antlers, and Leather

Bone, antler, and leather artefacts found in waterlogged conditions are also the subject of reproductions and experimental testing. As is the case for basketry and textiles, the majority of experiments concerning bones, antlers, and leather focus mainly on technology and function. Experiments such as the reproduction and testing of the Late Bronze Age Clonbrin leather shield (Coles, 1962), or the reconstruction of Ötzi's shoe (Reichert, 2000), are still very fashionable today. However, a new trend of experiments more concerned with hidden aspects of raw material and particular working techniques has been developing recently. One area of research that is particularly active is the study of the properties of raw materials and their suitability for making specific objects. For instance, more and more scholars agree that the ease of working fresh bones and antlers (as opposed to dry ones) implies the possibility of a material used immediately (e.g. soon after the animal is killed or the antler is shed) (Schibler, 2001*a*). Alternatively, the raw material could have been kept moisturized with water or other substances until it was used. One of the best examples of the ease of working fresh or wet antlers is the reproduction of a bracelet made of an antler beam splinter (*c*.1.5 cm wide and 15 cm long). The splinter was ground down to a thickness of less than 1 mm, bent (as a semi-circle), then held taut by means of a thin string passed through two tiny perforations in its extremities (see Fig. 7.19). The original artefact was found at the Neolithic lacustrine settlement of Arbon-Bleiche 3, Lake Constance (Deschler-Erb et al., 2002).

Experiments with leather have moved towards a more scientific approach, focusing on a better understanding of tanning and curing techniques (Groenman-van Waateringe et al., 1999). An area of research that has been particularly active in the past decade is linked to natural preservation of both bones and leather (including animal skin). The experimental burial of cattle bones

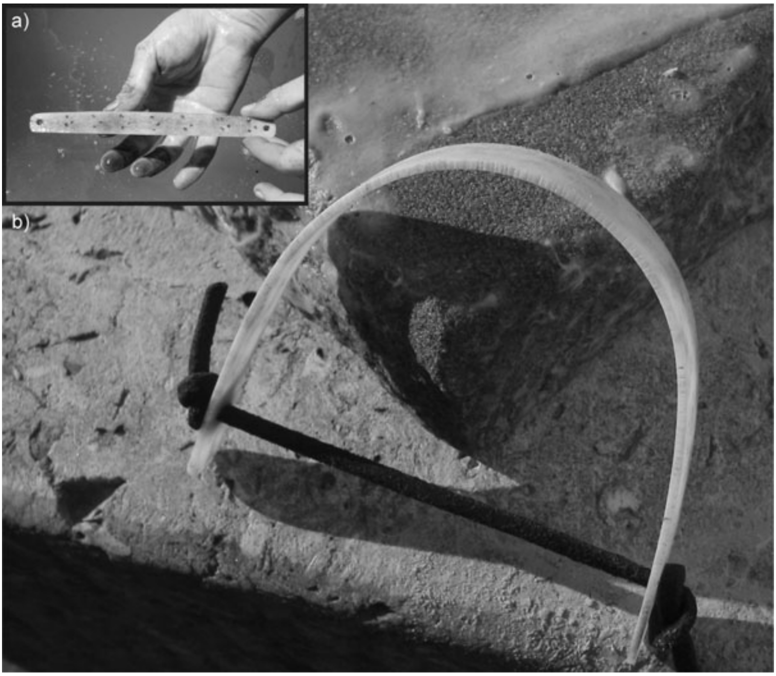


Fig. 7.19. Bracelet made of a finely worked antler beam splinter (replica of the original found at Arbon-Bleiche 3, Lake Constance, Switzerland): a) Straight shape; b) bent shape tightened with a thin string. (*Photographs*: courtesy of Jörg Schibler, IPNA, Basel University, Switzerland)

and pigskin in different waterlogged environments (raised sphagnum bog and fens) in Norway and Denmark has confirmed that the chemical composition of water and soil play a crucial role in the preservation of both bones and skin (Turner-Walker and Peacock, 2008) (see also Ch. 5).

EXPERIMENTING WITH AGRICULTURAL TECHNIQUES

Another main focus of experimental archaeology is testing ancient agricultural techniques, from the simple use of agricultural tools (to till the soil, or harvest crops), to more complex cultivation processes. This field of experimental archaeology is now embarking on a new research perspective, whereby these two aspects of agriculture are holistically considered in tandem. Percentages of crop remains found in archaeological sites are no longer accepted as evidence *per se*, but they are now tested against land availability (around the site), soil

productivity (see Ch. 3), and contemporary (to the occupation) technology (e.g. agricultural tools and cultivation methods) used for crop production. It is only by taking into consideration all these lines of enquiry that archaeologists will be able to make much more accurate estimates of the efficiency of ancient cultivation techniques.

Testing Agricultural Tools

Since a large number of ancient agricultural artefacts were made of organic material, the majority of archaeological evidence would be only indirect if it were not for waterlogged sites. In fact, as the main part of the artefact has disappeared, it would be no more than a guess that a series of scattered flints might have been part of a composite cutting implement (e.g. a sickle), or that the furrows spotted on chalky soil underneath the fertile stratum were produced by ards or ploughs. Thanks to waterlogged sites, archaeologists are not only able to see the complete object, but can also reconstruct it and test its efficiency. The first systematic attempts to reconstruct ancient agricultural tools date back to the 1940s, when Steensberg (1943) tested a series of flint, bronze, and iron sickles carefully replicated from originals found in northern European archaeological sites. Unexpected results revealed how some flint cutting implements could have been more efficient than metal ones for harvesting crops. The efficiency of flint harvesting tools was also emphasized by Reynolds (1967) in the 1960s, and more recently by Pétrequin et al. (2006*b*). It is, however, understood that their performance varied considerably. Pétrequin et al. (2006*b*) have, in fact, been able to show that the performance of different types of harvesting tools depends upon the way they are used. For instance, testing a number of sickle-like cutting implements from the entire Circum-Alpine region (spanning the second half of the fifth millennium to the end of the second millennium BC, see Fig. 7.20), it became evident that the Egolzwil and Riedschachen types were particularly suitable for oblique cutting (Fig. 7.21), as opposed to the Pfyn, Clairvaux, and Horgen types whose performance in such cutting was fairly mediocre. Similarly, the suitability for sawing of the Niederwil and Fiavé types was certainly not matched by the Hitzkirch and Twann types (Lobert, 1995; Pétrequin et al., 2006*b*: 112).

It is interesting to notice that all these tools not only reflect a chronological evolution of the various tool types, but also trace a cultural development of new harvesting methods. An area of research strictly linked to use and function of harvesting tools is surface residue analysis. The various techniques range from simple testing of different cutting implements on different materials, pioneered by Spurrell (1892) in the nineteenth century, to more complex applications of use-wear (Jensen, 2001) and protein-residue analysis (Högberg et al., 2009). Since all cutting implements are made of composite

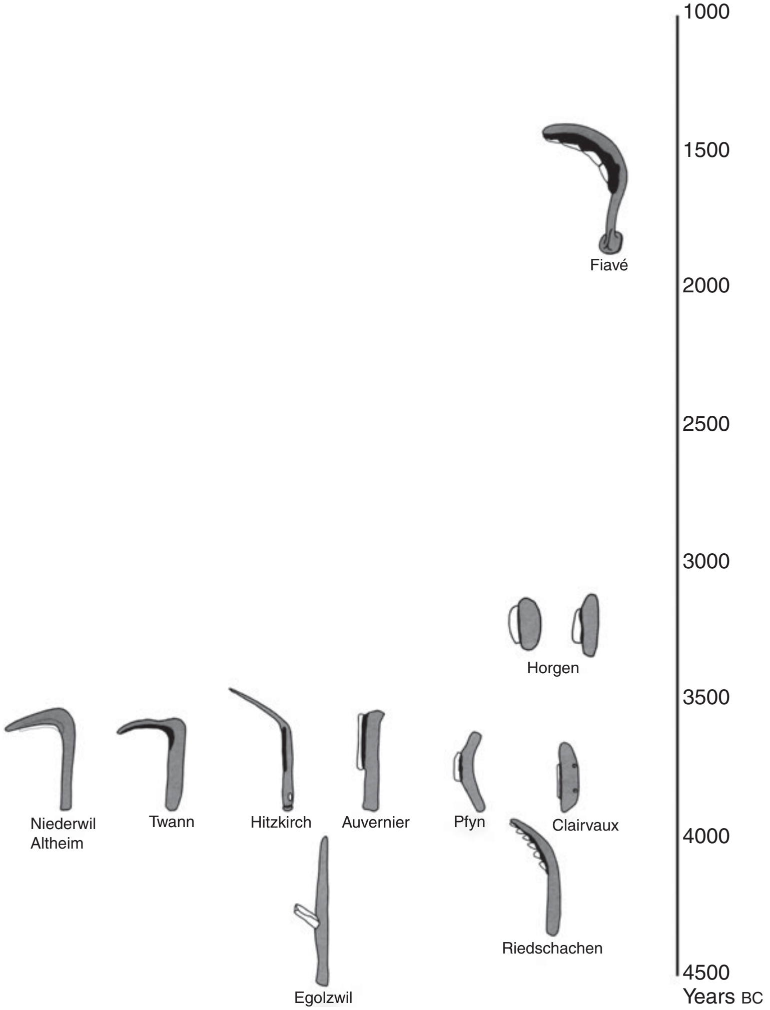


Fig. 7.20. Typological classification of lake-dwelling harvesting tools from the Neolithic to the Bronze Age. (*Drawings*: courtesy of Pierre Pétrequin, Laboratoire de Chrono-écologie, CNRS, Besançon, France—Graphic: Ben Jennings)

materials (e.g. flints and wood), experiments of tar (as a form of glue) production, to secure the flints on the wooden part (handle), have also been part of the harvesting tool testing studies (Osipowicz, 2005). Another agricultural tool with a long history of experimentation is the plough (including the ard). Pioneering work dates back to the 1960s, when an Iron Age (*c*.350 cal BC) wooden ard, recovered from a peatbog at Hendriksmose (Jutland, Denmark), was replicated and tested at the Lejre Research Centre (Hansen, 1969). Since

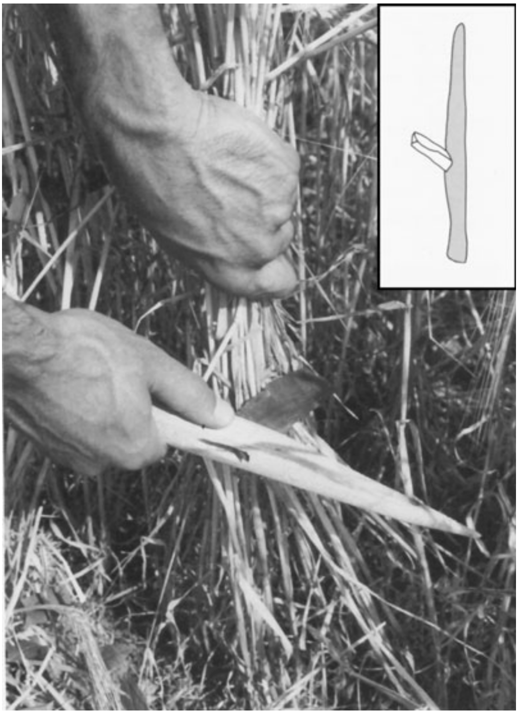


Fig. 7.21. Experimental use (on wheat) of an Egolzwil-type sickle reconstruction. (*Photograph*: courtesy of Pierre Pétrequin, Laboratoire de Chrono-écologie, CNRS, Besançon, France)

then, experimental archaeologists have come a long way in understanding the various types of plough/ard, their composite structure, and the delicate relationship of their components (e.g. the beam, stilt, mainshare, and foreshare). It is furthermore crucial to understand how the plough is attached to the draught animals, and how the latter behave according to different types of soil. Since all these variables are clearly reflected in the archaeological evidence (abrasion, wear of the shares, angle of the beam, etc.), it is vital to record ancient ploughs/ards as soon as they are found. In fact, even a minor distortion can influence the reproduction of the artefacts and possibly compromise the final result of the experiment.

Experimental Crop Cultivation

We have so far seen how helpful experimental archaeology can be in shedding light on the use and function of ancient agricultural tools. The importance of

understanding how and why specific tools were used in a particular way rather than another is ultimately linked to the main objective that ancient agriculturalists had: to obtain the best possible results, with the least possible effort. It is clearly understood that no matter how technologically advanced the tools were, the natural environment (e.g. soil, water, and climate) and cultivation techniques still played a crucial role in the final outcome. Evidence of different methods of cultivation may still be identifiable in the archaeological record. What is, however, no longer visible is whether or not these methods were good enough to yield satisfactory results in terms of crop production. The cultivation of experimental crops can be, in this case, of great help. Experimental work in this field also has a long research tradition, one that dates back almost one hundred years. One of the first attempts was carried out by Franke and Watson in the Mesa Verde National Park (United States) in the late 1910s. The results of seventeen years of experiments were remarkable (Franke and Watson, 1936). Light was especially shed on germination tests, hydrology, crop rotation, and combined cultivation. The latter two in particular proved that combining a rotation of bean and corn cultivation improved productivity without depleting the soil. In fact, while corn exhausts the nitrogen in the soil, beans put it back, thus maintaining an acceptable fertility level.

Since the Mesa Verde experiment, a number of such studies on crop cultivation have been attempted. See, for instance, those of the Draved Forest in Denmark (Steensberg, 1955; Troels-Smith, 1990), Reynolds' experiments at the Buster Ancient Farm (Reynolds, 1977) and, more recently, that of Meuerers-Balke and Lüning (1990) in the Hambacher Forest, Germany. Two of the latest experiments on crop cultivation were initiated at Wackershofen and Forchtenberg (central Germany) in the mid to late 1990s. The experiments were to clarify different, sometimes contradictory, archaeo botanical results on Late Neolithic cultivation in the northern parts of the Circum-Alpine region (mainly the surroundings of Lake Zurich and Lake Constance). Before the experiment, archaeobotanical studies in this area argued for three kinds of cultivation: (*a*) permanent crops without fallow phases (Maier, 1999), (*b*) crop rotation with short fallow periods (Brombacher and Jacomet, 1997), and (*c*) shifting and slash-and-burn cultivation (Rösch, 1996, 2000). The Wackershofen and Forchtenberg experiments have shown that yields of bread wheat with slash-and-burn cultivation are much higher than those obtained with the three-field system (fertilized fields used for longer time) (Rösch et al., 2002, 2008) (see Fig. 7.22).

However, it has to be taken into account that landscape consumption under shifting (slash-and-burn) cultivation is quite high (and it becomes even higher if woodland used for fuel is considered). It is therefore clear that the ratio of efficiency to productivity depends on the demand and availability, or, more precisely, on what people need and what the landscape can offer. The fact that these two later experiments proved a much higher efficiency of the slash-and-burn

Fig. 7.22. Experimental crop cultivation at Forchtenberg (Germany), showing different results in wheat yields, between cleared and burned forest areas and non-burned terrain. (*Photograph*: courtesy of Otto Ehrmann)

technique as opposed to other methods does not confirm that this was the preferred or the more affordable technique. In fact, due to the intrinsically interwoven social and environmental factors, people were sometimes forced to adopt methods that were less efficient or even counterproductive. For example, Neolithic and Bronze Age lake-dwellers of the Circum-Alpine region certainly knew that the slash-and-burn technique was the best option; in some areas though, they simply could not afford it any more in the way their ancestors were able to.

Regardless of whether or not experiments on crop cultivation are able to show what methods were preferred by a specific group, they can provide invaluable additional information on vegetation change, long-term development of soil, and forest management, which is not always evident with more conventional scientific analyses (see Ch. 6).

DEPOSITIONAL AND SITE FORMATION PROCESSES

As stressed throughout Chapter 6, a better interpretation of the archaeological record is obtained with a more holistic understanding of the site formation processes, which not only take place after the site is abandoned, but most importantly during the occupation. Despite seminal studies on the various processes that lead to the formation of the archaeological site (Binford, 1981,

1983; Schiffer, 1987), there are still a number of depositional aspects that are not fully understood. ‘Artificially’ reproducing anthropogenic deposition processes on an experimental site may seem useless and farfetched. How can, for instance, a ten-year long occupational pattern in and around the house be condensed into a two-month long re-enactment of the process? The answer is very simple: it cannot. However, the amount of information available to archaeologists who excavate that ‘artificial’ site (only a relatively short period after the site was created) is far more abundant than that available at a millennia-old site. In short, what has been lost forever in those millennia is still available at the experimental site, and that information can be integrated into the final archaeological understanding.

The Experimental Earthwork Project (Bell et al., 1996) is considered to be one of the milestones of experiments in site formation processes. The project consists of two earthworks, Overton Down (Wiltshire) and Morden Bog (Dorset), purposely built in 1960 and 1963 respectively, in order to be systematically studied (excavated) at regular exponential intervals (e.g. 1, 2, 4, 8, 16, 32, 64, and 128 years) over more than a century. The astonishing results obtained in the first thirty-two years of the project have enriched and contributed to the development of a number of science-based archaeological analyses within several disciplines. Although the two earthworks have nothing to do with waterlogged sites, part of the analytical work (e.g. preservation of biological and environmental evidence, with a special emphasis placed upon micromorphological and microbiological studies) developed during the project has been applied to wetland archaeological research as well.

Living Floors and Refuse

Identifying how the living floor of an ancient house was formed is crucial to the understanding of human activity in and around the dwelling. With the help of archaeological evidence and ethnographic studies, numerous experimental reconstructions of living floors have been carried out (e.g. at the Lejre Experimental Centre, the Buster Ancient Farm, etc.), in order to recreate ‘real’ living conditions and depositional processes. The results have then been studied (through excavation and scientific analyses) and compared with the archaeological record. Although it is often assumed that living floors of houses within a waterlogged context are a Pompeii-like reflection of the original (at the time of occupation) floor, this is, in most cases, not correct. Preservation does not depend only on the environment, but also on the type of floor. It is therefore important to identify whether the floor is a stable/byre, a beaten floor (compressed soil with no wooden or clay surface), a ground-level wooden floor (roundwood or planks), a ground-level wooden floor with a clay surface, or, finally, an elevated floor (a floor on stilts that can be made of roundwood or

planks and sometimes coated with clay). Although certainly not a straightforward process, the identification of the activity areas in the first four types is much easier than in the last one. Soil chemical analyses may also be difficult. For instance, while beaten floors absorb (even if cleaned regularly) whatever is spilled and trampled on, wooden or clay floors do not (Middleton and Douglas-Price, 1996). Hence once (or if) the wooden surface disappears (e.g. is taken away), the chemical content of the surface beneath may not reflect the activities carried out on it during occupation. Identification becomes even more complicated with elevated floors, for they are most of the time displaced from the original position and/or completely destroyed when they collapse on the ground (Dieckmann et al., 2006). The discarding of refuse around the houses has always been a topic of great discussion in wetland archaeology. The elevated floors and the close proximity of the houses in some prehistoric lacustrine villages of the Circum-Alpine region have always intrigued scholars as to where the daily waste was discarded. In order to shed more light on this issue, a few experiments on refuse discarding have been initiated. The abovementioned experimental houses on Lake Chalain (France) and Unteruhldingen (the Hornstaad-Hörnle house) on Lake Constance (Germany), were systematically inhabited for a period of time and the refuse produced was discarded outside or near the house. In the case of the Hornstaad-Hörnle house, the area was subsequently studied a year later (see Fig. 7.23a, b, and c) (Krauss et al., 1999). The Chalain experiment was more concerned with living conditions inside the house. One of the main achievements was the study of the fireplace smoke in the house without a chimney. Incredible as it may seem, it was realized that the first 1.5 metres above the floor inside the house would not be engulfed by smoke, which would collect only in the upper roof. This not only had the advantage of preserving the thatch, but would also keep the interior free of flies and mosquitoes in the summer, and maybe even mice in winter (Monnier et al., 1991: 20).

As shown by Fig. 7.23, the lake-dwellers would discard their rubbish at either at the back or the front of the house, depending on the location of the main street in relation to the house entrance. In some cases (as in Arbon-Bleiche 3), the presence of a rubbish flap on the floor (see Fig. 7.24) would also have been possible, since discarded waste was discovered underneath the elevated floor (Jacomet et al., 2004; Leuzinger, 2000). Another important factor that has to be taken into account is whether the ground below the elevated floor was dry or flooded (perhaps seasonally). In case of a permanently or periodically flooded lake shore, it has been shown that artefacts become transported more readily in a oscillating rather than linear flow, indicating that even in 'quiet' waters, profound disturbance may occur. Also patterns of discarded bone deposition vary considerably, and a clear distinction can be made between lake margins and riparian environments (Shackley, 1978; Thayer Morton, 2004). Finally, another important factor in periodically

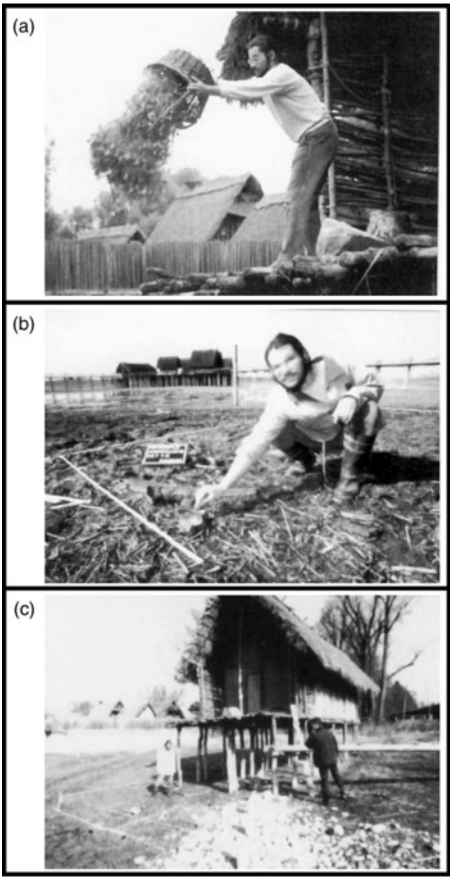


Fig. 7.23. Depositional patterns of discarded rubbish, experimentally recorded at Unteruhldingen, Lake Constance, Germany: a) discarding process; b) and c) recording process. (*Photographs*: courtesy of Gunter Schöbel, Pfahbaumuseum, Unteruhldingen, Germany)

flooded environments near habitations is the effect of trampling. Micromorphological analyses and systematic experiments on surface trampling have demonstrated that ancient trampled wet deposits differ significantly from dry ones (Rentzel and Narten, 2000). The effect of trampling on wet surfaces impacts deeper into the ground than it does on dry sediments.

House Destruction

Whether intentional (Chabanuk, 2008), or accidental, wooden house conflagrations happened quite often in the past. Sometimes it affected only

Fig. 7.24. A rubbish flap (rectangle) reproduced in the Arbon-Bleiche 3 experimental house (no. 23) constructed at the Pfahlbaumuseum, Unteruhldingen, Germany. (*Photograph*: courtesy of Urs Leuzinger)

one or two houses in the settlement, but fairly often, because of the close proximity of the houses, the entire village would have been destroyed (see e.g. Lattrigen-Rütte, Lake Biel) (Hafner and Suter, 2004: 23). During the excavation, archaeologists often come across burnt houses, but to distinguish between a structure purposely set on fire, and one burnt accidentally, is extremely difficult. However, the wide gap between archaeological evidence and cause of the fire can be partially bridged by house-burning experiments. Pioneer work on this research topic started in Denmark in the 1960s, when a replica of a full-scale Iron Age house was set on fire and the entire destruction process, as well the final excavation six months later, was thoroughly recorded (Hansen, 1966; Nielsen, 1966). Following a careful consideration of the remains, it was soon realized that not only would the experiment help archaeologists recognize site formation processes (during and post-conflagration), but, since construction elements and techniques of a house have direct implications on the way the house burns and collapses, the experiment would also allow archaeologists to identify those construction techniques and the material used. This will eventually facilitate the full reconstruction of the house. Such results were subsequently corroborated by an unplanned conflagration that accidentally destroyed two large, full-scale LBK house

replicas at the Archeon Centre in the Netherlands. After recording all the remains of the two destroyed houses, archaeologists came to the conclusion that important data could be gained only if all details of the house construction techniques had been previously recorded (Flamman, 2004). Both experiments (the planned and the accidental) have shown us two important points. First, how easy and quickly a quite large house (the largest house at Archeon was about 30 metres long and 7 metres wide) can be destroyed by fire; and second, that even with a careful pre- and post-conflagration recording of data, the remaining archaeological evidence is very limited. All this should lead to even greater appreciation of those unburnt waterlogged sites that still retain fairly intact architectural details of dwellings (Gollnisch-Moos, 1999).

CONCLUSION

Despite the large amount of information available from waterlogged archaeological sites, archaeologists are often faced with seemingly unanswerable questions. Ancient objects may have had specific functions with which we are no longer familiar. Throughout the chapter it has been seen how experimental archaeology can help identify, test, and understand the function and technology of archaeological objects. However, not all experiments are carried out with the same purpose. There are, in fact, three levels of experiment, within which different efforts and achievements are encompassed. Level one is concerned with appearances only (e.g. reproductions for museum displays), level two tests the technology linked to the process of production and manufacture of the ancient objects, and finally, level three is concerned with the use and presumed (sometimes speculative) purpose of the artefacts. A fourth level, which is becoming more and more part of the experimental process, crosses the boundaries of physical archaeological evidence and causes the human agency that made the objects become the focus of the experiment. It is interesting to note how some experiments (e.g. the house reconstruction linked to functionality, human activity, and site formation processes) cover all these levels, while others (e.g. replicas for museum displays) may not go beyond level one.

Since the archaeological reasoning process begins with the excavation, it is therefore crucial to understand how the site itself was formed. Experiments on site formation processes, including deposition during the occupation, as well as post-abandonment taphonomic developments, are becoming an integrated part of experimental archaeology. Sometimes what we see sealed in the stratigraphic sequence does not correspond with what really happened, and this is not always understood until levels three and four are fully taken into

consideration (see the stratigraphic sequence of occupation of Arbon-Bleiche 3, Box 6.2).

Experimental archaeology has now entered a new phase, where human agency has become the main focus of research. Archaeologists are no longer satisfied with a simple understanding of object technology and functionality, they want to know more about the people who made the artefacts, their socio-economic involvement, and their beliefs, both sacred and profane. Not only has experimental archaeology already included all four above-mentioned levels of experiment, but thanks to the latest computer technology, it is now developing new analytical tools capable of integrating and elaborating a myriad of different socio-economic and environmental variables (Pollmann et al., 2007), which will eventually be able to simulate reliable accounts of past ways of living.

8

Wetland Archaeology in a Wider Context

INTRODUCTION

Despite long-running, animated debates in the past few decades, the question as to why our ancestors decided to inhabit seemingly inhospitable environments such as the wetlands still remains. A strong empirical functionalist approach to research has induced environmentally deterministic explanations, but one now knows far too well that there is more to this than meets the eye. What is clear though, is that in trying to solve the enigma, wetland archaeologists have in some cases not only failed to integrate the discipline into mainstream archaeology, but also even detached wetland sites from their surroundings. Settlements within the wetlands are often seen as synchronic oases in the landscape. Considering examples from northern Europe (the Netherlands, Denmark, and Germany), the British Isles and Ireland, the northern Circum-Alpine region (Switzerland, Germany, and France), and northern Italy (Viverone, Piedmont) this chapter shows that such separation (culturally and geographically) is simply illogical. In most cases one is dealing with a single cultural group within different environments. Placing decontextualized wetland sites in a wider sociocultural as well as geographical context would therefore promote less biased interpretations.

As argued by Van de Noort and O'Sullivan (2006), wetland archaeology should be fully aware of the current archaeological debate and contribute to the broader aspects of archaeological research. More emphasis should be placed on people's identity and their social world, and the wetlands themselves should be considered more from the insider's point of view rather than using counterproductive meta-narrative.

The discipline has often been criticized for not having a solid body of theory, or in fact, not having any theory at all. But is theory really missing within the discipline, or it is just that wetland archaeologists do not want to use it? Due to the high quality of archaeological evidence, wetland archaeologists have mainly adopted a strong empirical functionalist approach to research, assuming that archaeological evidence will speak for itself. As a result, they have oriented the discipline in an environmentally deterministic

direction, whereby only the exploitative relationship between people and their environment is considered.

It is important to point out that the isolation of wetland archaeology from mainstream archaeology has not occurred in the same way everywhere. It is more pronounced in the Anglophone world (e.g. the United Kingdom, Ireland, and the United States), where the archaeological reasoning has always been more theoretically oriented (see also Ch. 1). Where theoretical approaches to research were/are not strongly part of the local research tradition, and wetland sites were/are not distinguished or separated from the dryland ones, the scission between the two branches has not occurred.

However, regardless of whether or not wetland sites are considered part of mainstream archaeology, their general potential for a better understanding of people's past is still largely underestimated. The high resolution of data available within waterlogged contexts could not only be used by archaeologists, but also included in much larger research schemes that go far beyond archaeological studies (e.g. geography, climatology, geology, etc.). Furthermore, they could be used either to test the validity of existing theoretical approaches or even to develop new ones. One has to be careful, though, not to force inappropriate approaches into the archaeological process just for the sake of it. Theory should serve archaeology and not vice versa. It has been argued that 'new' theoretical approaches should be developed to suit the peculiar characteristics of wetland archaeology, but would it be appropriate to consider already existing theories inapt just because they have never been applied within wetland archaeological contexts before? Because of the peculiarity of some archaeological assemblages, some approaches are certainly more suitable than others, and may lead to better results. However, since the body of theory within mainstream archaeology is already fairly rich, it is perhaps better to try integrating it into wetland archaeology rather than develop 'new' approaches, which could possibly widen the already existing separation.

The purpose of this chapter is not to criticize wetland archaeology (this has already been done eloquently by Scarre 1989, Evans 1990 and Tilley 1991), but to stand back and point out its weaknesses as well as its potentials. It is indeed by putting the discipline into a wider context that possible new directions for a long-overdue (re)integration can finally be found.

DIFFERENT APPROACHES TO WETLAND LANDSCAPE

When examining wetland landscapes, it is vital to take into account that they represent creations, re-creations, and manipulations, which have been

developed within specific sociopolitical contexts. A hermeneutic approach to landscape studies is therefore required, in order to avoid biased representations. It is furthermore important to distinguish between the various wetland ecosystems as they may have been perceived by ancient communities, for the word 'wetland' itself did not mean anything to those groups. Van de Noort and O'Sullivan (2007: 81–4) suggest a series of characteristics that should be considered, when studies on people–wetlands interaction are carried out.

First of all, wetland landscapes should always be contextualized in both spatial and temporal ways. There is a frequent tendency to isolate archaeological sites geographically and chronologically, without taking into account the immediate surroundings. However, in the majority of cases, although the sites may be in, or on the edge of, a wetland ecosystem, most of the activities (including social interaction) occur on drier ground. Geographical contextualization should be done at various scales (local, regional, and interregional), including, if possible, long-distance trade networks, and it should also incorporate temporal developments, such as diachronic considerations of cultural chronologies that surround the archaeological site(s). Finally, theoretical approaches used in relation to the single scholar's research tradition should also be made explicit, in order to avoid biased interpretations.

The general term 'wetland', used to refer to a number of wet ecosystems that incorporate archaeological remains, should not become the basis for cultural analysis. As Van de Noort (2004*a*) argues, not all wet environments in the Humber wetlands (northern England) were considered in the same way, in later prehistory. In fact, while the alluvial wetlands yielded a fairly large number of hunting camps, flint production areas, field systems and settlement sites, the peatlands lacked those finds, yielding instead more ritually deposited objects. However, this type of perception of the wetlands was not the same everywhere. For instance, a continuous change in the political structure in northern Holland in the Early Medieval period has progressively transformed marginal peatbog areas into attractive places to live (Besteman, 1990). This transformation was only possible thanks to the creation of local ecologies by people who knew the area very well and were therefore able to make the most of the available resources.

Another crucial point to be considered is the understanding of specific landscapes from the point of view of people who inhabit(ed) them. The perception of the environment varies a lot from people to people, and, most importantly, it changes considerably between insiders and outsiders. This is beautifully described by Wilfrid Thesiger in his book *The Marsh Arabs* (1964), where the 'idyllic' life of the marsh dwellers (the insiders), contrasted sharply with the view of the Iraqi government, who saw the marshes as a negative place, full of bandits and rebels (Thesiger, 1958). Van de Noort (2004*a*) provides a similar example with the Humberhead Levels (northern England) in the seventeenth century, when the drainage of Hatfield Chase caused

significant friction between the royal authorities and the commoners, who, unlike the former, appreciated the various natural resources available within the wetlands.

A vital aspect of wetland landscape studies is the consideration of the natural environment as extremely dynamic, perhaps even 'alive'. People enculturate their surroundings in various ways. One of the first forms of landscape enculturation was the construction of 'roads' (e.g. paths, wooden trackways, causeways, alignments, etc.) to penetrate the unknown. As a result, the environment started to reflect how people interacted with it (Tilley, 1994). In this way, a 'road' does not simple connect two places, but it transforms the uncertainty of 'wilderness' into a more familiar enculturated landscape. This concept is particularly apt for wetland studies, as those environments often contain the archaeological remains of wooden trackways, ranging from the Neolithic to the Middle Ages (Bauerochse, 2003; Casparie, 1987; Raftery, 1990, 1996*d*) (see also Ch. 4, under 'Within and Between the Wetlands: Trackways, Causeways, and 'Roads''). The study of landscape enculturation through wooden trackways found in bogland areas is a particularly delicate topic, and has to be considered carefully in relation to the above-mentioned site contextualization. In fact, thorough analyses of the various wooden trackways from all over Europe show the many functions that those 'roads' had. Some of them did indeed link two places; others, in contrast, penetrated the wetlands only partially. Artefact distribution around them may tell us a story that is sometimes totally different from that told by environmental studies. It is therefore vital to 'zoom out' and include the synchronic site(s) within a wider diachronic spatial and temporal context.

Strategic locations (e.g. boundaries of territories) of the wetlands and wetland archaeological sites are also to be considered with attention. R. Bradley (2000) calls these places 'natural places', while Stocker and Everson (2003), as well as Field and Parker Pearson (2003), show eloquent examples of long use of some of these natural places in the wetland, whose use and significance (not necessarily the single archaeological sites themselves) perpetuated through centuries.

Two concepts in wetland archaeological studies that are often confused are marginality and liminality. The latter, originally developed by van Gennep (1908) is usually linked to formalized rituals and practices that accompany the transition from one stage (e.g. of life), to another by crossing the undefined threshold (the liminal zone) located between the two defined phases (e.g. from childhood to adulthood). Although in some cases liminality is present in marginal places, the concepts are distinctly separate, and, in fact, rites of crossing liminal zones are often performed in well-frequented popular places. An example of liminality that is definitely not connected with marginality is provided by Fletcher and Van de Noort (2007: 316–18), with the wooden trackway of West Furze, in the Holderness region. The function of this

trackway (especially the doorway) is believed to have symbolized the liminal space between the two worlds: the living and the dead. Because of its strategic location, the site is definitely not regarded as marginal.

It is finally important to consider wetland landscape as taskscape, whereby the way in which the landscape is perceived and experienced is strictly related to the different activities (tasks) that are undertaken within that landscape at any particular time (Ingold, 1993, 1995, 2000). This way of considering the landscape highlights the importance of the insider's view, and how all the various activities, which are carried out by people living and working in the same context (the landscape), are not simply economic activities, but also contribute to the moulding of specific social and cultural conditions as well as social identity.

It is not suggested here that all the above-mentioned aspects of wetland landscape research should be substituted for traditional and more scientifically and/or environmentally determined approaches. Rather, they should help contextualize and analyse the wetlands and their archaeological sites in a more holistic and hermeneutic way. A combination of both insiders' and outsiders' perceptions would facilitate and improve our understanding of the wetlands, as well as those people who used to (and in some cases still do) roam, exploit, and inhabit them.

TEMPORAL PERSPECTIVES

Wetlands and Temporality

Before the advent of precise absolute dating techniques (e.g. dendrochronology), the wetlands had often been perceived as timeless representations of perseverance and continuity. The stratigraphic succession of human activity used to give us the idea of impressive continuity, apparently undisturbed by any external historical and political influence (Gosden, 1994). However, as our chronological understanding of events improved, it was soon realized that not only did the various traces of human–wetland interaction show more 'discontinuous' continuity, but that external influence was sometimes very pronounced. For instance, the traditional model arguing for marginal and isolated locations of early monastic sites in Ireland may be contradicted by the number of *toghers* (wooden trackways) found in the wetlands surrounding the bog island of Lemanaghan (sixth century AD). This communication network with ancient origins may in fact have been the reason why such a strategic location was chosen in the first place (O'Sullivan and Van de Noort, 2007; Stout, 1997). The choice (or availability) of dating techniques plays a crucial role in understanding temporality in the wetlands. What ^{14}C highlights as 'continuity'

may result in a series of isolated events, possibly not even culturally connected, when more precise dating methods (e.g. dendrochronology) are applied. Examples of such misinterpretation of continuity are found everywhere, from the typical peatbog trackways of northern Europe, Scandinavia, the British Isles, and Ireland (see Ch. 2:, under 'Europe', and Ch. 4, under 'Within and Between the Wetlands: Trackways, Causeways, and 'Roads''), to the lake-dwelling tradition of the Circum-Alpine region (see below, and Ch. 4). Long-term patterns of occupation may be better interpreted as short-term events, influenced by both cultural and environmental factors. People's decisions and agency according to the strong influence of very dynamic environments may also contribute to shape continuity. However, even if the decision-making includes opportunistic actions dictated by constantly changing dynamic surroundings, the influence of previous actions (e.g. linked to tradition of memory evoked by visible archaeological remains) does affect, and sometimes even shape, continuity and perpetuation of cultural traits. Typical examples of past (and present) communities' lives influenced and shaped by long- and short-term repetitive and highly dynamic environmental factors are found in estuary areas and river floodplains (see e.g. fish-traps and weirs in the Shannon Estuary, Ireland; the Severn and Blackwater estuaries, United Kingdom; and the large number of estuaries on the Northwest Coast of North America) (Bell, 2007; Bell et al., 2000; Ivy and Byram, 2001; Moss and Cannon, 2011; O'Sullivan, 2001*c*, 2003*a*, 2005; Rippon, 1997, 2001*a*, *b*; Stevenson, 1998) (see also 'Seasonality' below; and Ch. 4, under 'Weirs and Fish-Traps').

Cultural Biography

Thanks to the well-preserved and highly detailed archaeological remains found in waterlogged conditions, the study of cultural biographies of habitations and objects in general has become a fairly common practice in wetland archaeology. The latest approach to biographical studies of objects, also called 'cultural biography', differs substantially from the functionalist approach to life cycles. In fact, as the latter emphasizes manufacture and function (Gosden and Marshall, 1999), the former stresses the importance of the different phases that objects go through during their existence, and the different meanings that they acquire or lose (see also Gell, 1998; Strathern, 1988).

Life History Approach: The 'Living' House(hold)

Although cultural biographical research within wetland environments covers both movable objects and houses, it is with the latter (in particular waterlogged wooden remains of dwellings) that the most significant results have been obtained recently. Most of the studies have been inspired by anthropological

research carried out by Kopytoff (1986), who described the biographical developments of the Suku huts in Zaire, from their initial function (shelters for mothers and children) to the middle phase (guesthouses for visitors), and finally becoming chicken coops in the last stage of their existence. The high resolution of details found in waterlogged contexts allows the biography to be linked to crucial moments of a house's life cycle, such as the planning, the construction process, the occupation period (which includes all repairs, expansions, and/or internal modifications), and the final abandonment. It is, however, more important to focus on what houses ('living houses') do, rather than the evolution of their physical shape (Tringham, 1991, 1995). In other words, it is germane to look at the cultural backgrounds of the different life stages of the various domestic elements that make up the entire house(hold) (including the inhabitants) (Kopytoff, 1986). It is by adopting such a holistic approach to the study of the house biographic elements that social structure, reflected and determined by the single house itself, can eventually be better understood (Shanks and Tilley, 1987). As a result, there is finally the possibility of obtaining 'internal' explanations to the development of the house(hold), from the initial planning to the final abandonment, without necessarily relying on 'external' causes, such as the life expectancy of the wood (i.e. the material used to build the house), or environmental change (e.g. climatic variability, soil depletion, etc.) (Borić, 2007, 2008; Brück, 1999*a*, *b*; Gerritsen, 1999*a*, *b*, 2003, 2008) (see also Box 6.2). A final advantage of this approach is that it facilitates the analyses of patterns of occupation on a large scale, including, in some cases, the entire village. The analysis can eventually be expanded to identify specific plots of land in use within the settlement (the *Hausplatz*) and, if the availability of data allows, the genesis of the settlement(s) can even be linked to settlement rotation within specific *Siedlungskammern* (Billamboz, 2006; Krahn, 2006; Zimmermann et al., 2004) (see also Box 4.3).

Social Identity

Although, as previously discussed, people living and working within (and on the edges of) the wetlands do not necessarily belong to specific cultures (different from those of neighbouring, drier environments), it should be accepted that the social identity of those communities is somehow differently shaped. Social identity allows people to place themselves within a specific social context, providing them with all the information they need to survive and interact socially with each other (Meskell, 2001). Not only do people express their social identity by ordering and organizing their 'living worlds', but they also develop these via transformation and manipulation of their material culture (clothes, jewellery, hairstyles, food, etc.). Social identity can also be articulated through 'structuring principles' (Frazer and Tyrrell, 2000),

such as kinship, age, ethnicity, social class, ranking, sexuality, and political organization. It is true, of course, that people should be considered as part of specific cultural and historical communities, which, in some cases, span vast geographical regions. However, important aspects of social identity are formed within limited areas, where people spend most of their lives and where their traditions, collective memories, and restricted social practices take place, allowing them to engage with the dynamic of their constantly changing surroundings. It is in this sense that the environment (in this case the wetlands) becomes an active agent in the shaping of people's identity (Tilley, 2004). It is furthermore crucial to contextualize this 'formation of social identity', which itself is the result of a number of interwoven spatial and temporal historical factors. Historical aspects may also influence people's activities and professions. Their social role within society would shape different social classes, which would also contribute to outline social identity. For instance, although an entire community could be linked to a specific wetland environment, perhaps only part of that community works actively within the wetlands (e.g. hunters, fishermen, herders, etc.). Therefore, a society living in, or near, a wetland ecosystem may even have different variants of social identity. Another important aspect of social identity formation is its dual character. While structured social identities can be partly established or given to a person at birth, sometimes that person has the chance to alter and negotiate her or his social identity, with the possibility of developing even more fluid and interwoven multiple social identities. In other words, if the social-historical context allows it, people can define their social identity by changing their social relationships, for the latter is always constantly changing—a never-ending process of social identity formation (Wells, 1998, 2001).

Various examples of social identity formation within a wetland context come from the Early Medieval crannogs in Ireland. These cases demonstrate the possibility of applying similar theoretical approaches to earlier crannog sites, not only in Ireland but also in Scotland (O'Sullivan, 2001*b*). It is interesting to note that crannogs were use by both kings and marginalized groups. The isolation of the king's residence was to achieve 'social distance' and the reputation of power, being at the same time the centre of attention. This form of expressing social identity was, in a way, similar to the opposite side of the hierarchical ladder of society: the poor and marginalized people, who used similar isolated locations to maintain their social identity—physical isolation meant that the community was at 'the centre of people's lives' (Van de Noort and O'Sullivan, 2006: 75). Drainage of wetland areas in England in more recent times also provide examples of social identity within society, which resulted in unexpected political developments. The seventeenth-century drainage of part of the Humber wetlands, for instance, triggered discontent amongst the commoners (the wetland insiders), who eventually chose to take the anti-royalist side during the English Civil War. This move

was not predicted in sociopolitical terms, but it was essentially guided by the commoners' social identity (Van de Noort, 2004*a*: 160).

Special wetland environments that are particularly important for the study of social identities within past communities are the estuaries. These dynamic landscapes were far more than simple sources of economic benefit (see also 'Seasonality' below). In fact, by working within them, people developed a strong bond with long-lasting traditions that contributed to shaping their social identity. This is particularly evident in the Shannon Estuary (Ireland) during the twelfth to thirteenth century, when, despite the Gaelic Irish lordship having been diminished significantly by the Anglo-Norman military power, local fishing communities, thanks to their strong connections to the past (well-preserved ancient weirs and fish-trap remains are still visible on the shore) and their deeply rooted folkloristic traditions, were able to continue their activities in the same way as their forefathers had (O'Sullivan, 2001*c*, 2003*b*, 2005). Knowledge and access to the past contributed to the reinforcing of those local communities' social identity, which in the long run also facilitated economic relationships with the new incomers.

Seasonality

Seasonality can be linked to calendrical knowledge (including changing phases of the moon, solar activity, or even constellation patterns), or periodic changes of the environment (e.g. lake or river water-level fluctuation, wet and dry seasons, etc.), including variations in fauna (e.g. migratory activity of waterfowl and other animals). Although seasonal rhythms have always played a key role in all agricultural and hunter-fisher-gatherer societies within a variety of environments and at any latitude, in some specific wetlands those rhythms were (and often still are) even more important. Archaeologically, seasonal rhythms are identifiable in a number of wetland contexts; from lacustrine regions (see for instance Box 6.2 and Table 6.1), to fluvial and/or estuary areas. Estuaries were not only important for fishing activities (see above and Ch. 4, under 'Weirs and Fish-Traps'), but they were also used as grazing grounds. One of the best examples is found at Goldcliff, on the Welsh shore of the Severn Estuary. Here, palaoenvironmental studies, as well as spatial artefact analysis of the rectangular Iron Age houses, have confirmed that the salt-marshes were used as grazing grounds for cattle in the late spring and summer months. In winter, although the houses were not inhabited, the area was probably still exploited for other activities (e.g. waterfowling) (Bell, 1999, 2001, 2007). Similar scenarios of seasonal transhumance activity have also been noticed in the salt-marsh areas of Medieval Ireland (F. Kelly, 1997).

Useful insights for the study of seasonality in past and present environments comes from recent anthropological research in the Amazonian floodplains

(Adams et al., 2008; M. Harris, 1998, 2000, 2005; O'Reilly Sternberg, 1998). In his studies of the peasant communities of the lower Amazonian floodplains, M. Harris (2000) argues that seasonality is intrinsic to the current flow and quality of social life. The temporal sequence between different activities responds to periodic changes in the river, hence making seasonal variations also significant for social relationships and identities. Floodplain dwellers place seasonal change and its related factors in a socio-environmental context, whereby the wet season means hard times and less social interaction, and the dry period is seen as positive and prosperous, when all important social activities take place. During the wet season, people also tend to move to unflooded uplands and near the cities (Winklerprins, 2002). Interestingly, this tendency is also noted in prehistoric records, as it is shown by Denevan's 'bluff model of settlement' (Denevan, 1996), which is also confirmed by archaeological evidence (Roosevelt, 1999). Whether or not this mobility meant a dual residential strategy is, however, still open to discussion (Porro, 1994). Periods of flooding also lead people to manipulate the environment. The construction of mounds (or elevated grounds) for domestic use (crop cultivation) and the development of hydraulic systems in the form of channel networks was common practice in ancient times, as it is still today (Heckenberger and Neves, 2009; Raffles and Winklerprins, 2003; Schaan, 2010).

Finally, it is important to point out that this periodicity of social life is not environmentally imposed, but is the result of people's engagement with a constantly changing environment, integrated in their social interactions.

DIFFERENT LANDSCAPES, THE SAME PEOPLE

Not only do some countries find it difficult to integrate wetland archaeological research into mainstream archaeology, but in some areas even tend to regard wetland and dryland communities as two different entities, despite the fact that they may share the same environment. Some of the most significant cases are found in the northern Alpine region, where the sharp imbalance between lacustrine and 'inland' settlements (mostly due to taphonomic processes and particular research orientations), has led research to disregard the latter, thus compromising important cultural and chronological aspects of local prehistory. It has been owing only to more serendipitous discoveries in the past two decades or so that 'inland' sites have begun to be more and more part of the general archaeological reasoning, producing unexpected and surprising results concerning chronology and patterns of occupation. The first sign of change came with Fischer's study of a number of 'inland' Middle Bronze Age (MBA) settlements around Lake Zurich (Fischer, 1997). The research was significant as it showed the existence of prolific groups living away from the lake shores, but

possibly sharing the same environment and natural resources as the lake-dwellers. Unfortunately, a comparative analysis with contemporaneous lacustrine groups is not possible, as the MBA period (fifteenth to twelfth century BC) completely lacks lakeside settlements on any lake in the northern Circum-Alpine region (Menotti, 2001*a*). However, searching for the 'missing period', Menotti (2003) stumbled across more 'inland' settlements, some with possible lacustrine origins (after the lake shores were abandoned at the end of the sixteenth century BC), some others, on the other hand, with a long-established 'terrestrial' tradition (see e.g. the Hegau region, north-west of Lake Constance, Germany, and near Lake Zug, Switzerland) (Dieckmann, 1989, 1990; Gnepf et al., 1996). An irrefutable proof of MBA lake-dwellers moving away from the lake shores and sharing the environment with local 'inland' communities comes from the discovery of the Kreuzlingen settlements (Rigert, 1999, 2001). The sites clearly show their chronological inland shift, their establishment in the areas with other local groups, and finally, their return to the lake shores, as more favourable climatic conditions (and the retreat of the lake level) set in again, at the beginning of the Late Bronze Age (Menotti, 2004*a*; Rigert, 2001) (see also Box 3.2). A final confirmation of the significant presence of 'inland' settlement throughout later prehistory and beyond comes from the construction of the A1 motorway, just a few kilometres inland from Lake Neuchâtel and Lake Morat (western Switzerland). Here, a thorough consideration of the large number of sites has shown a remarkable continuity in occupation (spanning more than four millennia—see e.g. Bussy-Pré de Fond, with signs of occupation from the Neolithic to the Middle Ages), as well as a similarity in material culture with the neighbouring lacustrine settlements on the two above-mentioned lakes (Boisaubert et al., 2008; Mauvilly and Boisaubert, 2005). The study has made it evident that the 'inlands' were as heavily settled as the lake shores. It is clear now that the more research is carried out, the more vital links between the various groups will be established—concerning not only settlements, but also other archaeological evidence (e.g. the menhir alignments on the Bevaix plateau, western Switzerland) (Sedlmeier, 2003; von Burg, 2002).

The overwhelming number of exceptionally well preserved lacustrine settlements found in the northern Circum-Alpine region, during the 1970s to 1980s development boom, led scholars to neglect less attractive 'inland' archaeological sites, hence involuntarily creating a biased picture of regional prehistory. This tendency is not limited to the northern Circum-Alpine region but it may happen in other areas too, where the apparent discrepancy in settlement distribution between wetland and dryland is more marked. A region that might face this threat, at the moment, is the Midland counties of Ireland, where the large number of archaeological sites in the wetlands is certainly not mirrored by the surrounding drylands. This lack of settlements on drier ground is possibly due to preservation issues and the character of the landscape, but, as McDermott (2007: 19) points out, also to the ineffectiveness

of traditional archaeological survey techniques. This lacuna should be filled promptly if one does not want to fail contextualization processes discussed above, risking, once again, to widen the division between wetland and mainstream archaeology.

INTEGRATING OR INTEGRATED?

As discussed in Chapter 1, the isolation of wetland archaeology, as academic discipline, from mainstream archaeology is more a regional matter than a global issue. As a result, an obvious question arises: 'do we really need re-integration?' If the division is evident, the answer is certainly 'yes'. However, because of the various countries' different research traditions, the separation of wetland and dryland archaeology is not always present, and in some cases wetland sites are already well integrated into mainstream archaeological thought. Below there are a few selected examples of both sides of the coin, considered through a continuous 'zoom-in and zoom-out' process, in order to facilitate the contextualization of the single archaeological site(s).

Zooming In and Out

No matter how well preserved and detailed archaeological evidence is within a single site, that site will never be properly understood without placing it in a wider cultural, chronological, and geographical context. A continuous zoom-in and zoom-out process will therefore avoid biased synchronic generalizations and unsubstantiated conclusions as to the function and significance of the site. It has already been seen how the integration of wetland sites is a matter of research tradition as much as the single scholar's intellectual flexibility to cross conventional boundaries. However, there are some examples that clearly show that (re)integration can certainly be achieved, and in some cases, it has already (or has always) been done. It will be seen, for instance, that even the apparently most isolated prehistoric lacustrine villages in the Circum-Alpine region were often well connected to the external world, and that the different settlement dynamics between upland and wetland areas in the Netherlands' later prehistory is mainly due to different levels of preservation, as well as to unsuitable theoretical approaches (Gerritsen, 2003). It will also be seen that, thanks to the willingness of some scholars to adopt innovative approaches not influenced by biased research traditions, the 'integration' process is automatic.

A first example comes from a relatively small Middle Bronze Age (*c.*sixteenth to fourteenth century BC, with a final occupation in the Late

Bronze Age, eleventh to tenth century BC) lacustrine site on Lake Viverone, in the north-western part of Italy. Its rich archaeological assemblage (Bertone and Fozzati, 2004, 2006) is certainly not mirrored by any other contemporary site in its immediate surroundings. This may encourage us to interpret it as an isolated case with rather diverse sociocultural surroundings. However, a closer look at the material culture forces us to zoom out and take into account the entire region. By doing so (including also terrestrial and high-altitude settlements), it is soon realized that, despite minor local and regional differences, its cultural traits are widely spread. Moreover, a thorough consideration of Viverone's numerous bronze objects (including swords), links the settlement to long-distance trade networks that take us to the northern parts of the Alps, and even as far as the Danube (De Marinis, 1998, 2006). Trade connections and cultural similarities between the northern and southern slopes of the Alps are evident; but to what extent did the goods physically travel across the Alpine range? It is known, for instance, that the Erbenheim type of sword, which was characteristic of the northern Alpine region, is not represented in the southern parts of the Alps (e.g. the Italian peninsula) (Rubat Borel, 2006*b*). However, three two-piece stone moulds for Erbenheim swords have been found at Piverone, a few hundred metres away from Lake Viverone. The fact that the moulds were carved from a local (Champorcher Valley) type of stone, readdresses the importance of the northern Italian (in particular Piedmont) metal production for export across the Alps (Rubat Borel, 2006*a*).

Another example of the importance of integrating wetland sites into mainstream archaeological reasoning comes from the Netherlands, where recent life-history approach studies on wetland settlements has restructured settlement dynamics theories of later prehistory (Arnoldussen, 2008*a*; Gerritsen, 2003, 2004). The majority of theoretical approaches to settlement dynamics in the Netherlands were initially based on upland settlements. Following the discovery of a large number of wetland settlements in the lowlands (wetlands), it soon became apparent that they had the potential to question the validity of old and mostly biased upland models (Arnoldussen, 2008*a*; Gerritsen, 2007; Schinkel, 1998). In fact, the high-resolution archaeological evidence present in wetland contexts allows a more precise evaluation of the material culture, which leads to a more significant consideration of social processes and their influence on shaping settlement dynamics. It is therefore now possible to obtain 'internal' (within the single houses) explanations, as to how a dwelling (or even a settlement) developed, without necessarily relying on external causes (e.g. wood life-expectancy, and/or soil depletion, etc.). The results have been remarkable, showing that the life biography of houses, including their reconstruction and relocation, were not related to single-generational cycles (e.g. 20–25 years), but it extended far beyond that limit (e.g. 50–80 years). This showed the communities' intentional determination to perpetuate permanency in the area, and far more complex social relationships within the

settlement. It has became clear that houses were built and maintained in specific spots, for particular reasons, which were dictated by the groups' social organization rather than environmental factors.

Other models of settlement dynamics within wetland and drier terrain areas have been developed by Schlichtherle (2009), who, basing his theoretical approach on recent research developments in the Federsee area, has been able to demonstrate that the dynamics of settlement rotation changed from the Middle to Late Neolithic, when the settlements started to be occupied for longer and the area of rotation became more limited.

Examples of wetland sites being fully integrated into mainstream archaeology are to be found in other parts of Europe. In Denmark, for instance, the various sites found at Bjerre have all been considered within a wider geographical context, revealing not only links to the surrounding landscape (e.g. the barrows linked to the settlement system) (Rasmussen, 1995), but also cultural connections, as well as similar farming practices to those of West-Friesland in the Netherlands and the Schleswig-Holstein, northern Germany (Bech, 1997). Comparative analyses between the single house and palaeoenvironmental reconstructions of the area have also revealed a significant shortage in wood availability, which led to the use of peat as fuel (e.g. Bjerre 2—the earliest evidence in Denmark—*c.*fifteenth century cal BC) (Bech, 1997, 2003). Finally, it has even been possible to prove that the amber collection activity identified in various houses was not for local use (e.g. funerary practices and/or jewellery production), but it was collected for export to the south, via a complex down-the-line long-distance trade network (Bech, 2003: 57). This shows, once again, that these wetland communities were perfectly integrated at local, regional, and interregional level.

The importance of encompassing a wider portion of the landscape around the wetland (including dryland sites as well) is also stressed by recent studies in the Shannon Estuary. O'Sullivan and Breen (2007), for instance, argue for an intense exploitation of the estuary resources, which also include the drier and more elevated surroundings, especially as far as settlement locations are concerned.

From the above-mentioned examples it looks as if one can speak of full integration of wetland archaeological research into mainstream archaeology. Yet, 'all that glitters is not gold'! There are still some countries in which, because of their deeply rooted research traditions and excess of academic discipline pigeonholing, the process of integration is still in progress (and possibly has not even started). A positive perspective is that both research traditions (wetland and dryland archaeology) seem to be willing to share their results more and more, thus facilitating a more constructive way of bridging the unsubstantiated division.

THEORY OR NOT THEORY?

It is certainly evident that wetland archaeology, as an academic discipline, is not perceived in the same way everywhere. As a result the sense of isolation from mainstream archaeology felt in the Anglophone world (e.g. the United Kingdom, Ireland, and the United States) is not always mirrored in other countries. It is, however, true that because of the exceptional level of preservation of organic archaeological evidence, scholars in those countries where the separation and isolation of wetland archaeology did not occur, also did not, at the beginning, feel the need to integrate theory into the general archaeological corpus, assuming that the artefacts would speak for themselves. As a result, not only has the potential of wetland archaeology not been fully exploited, but in those countries with a strong theoretical research tradition the discipline has become more and more isolated from mainstream archaeology. This tendency has not only been clearly criticized by scholars, who are not necessarily involved in wetland archaeological research (Evans, 1990; Scarre, 1989; Tilley, 1991), but also within the discipline itself. In fact, in their book *Rethinking wetland archaeology*, Van de Noort and O'Sullivan (2006) eloquently highlight the various shortcomings of wetland archaeological research, suggesting a few solutions in order to start the long-overdue (re)integration process. For instance, in addition to stressing the importance of contextualizing wetland archaeological sites and avoiding meta-narrative of the wetlands, Van de Noort and O'Sullivan (2006) also point out how crucial it is to understand people's perception of their own environment (the insider's view) and the development of distinct cultural identities. Also to be stressed is the importance of various typical characteristics of wetland archaeological research (e.g. high-resolution dating and palaeoenvironmental reconstitutions linked together by Bayesean statistical methods of analysis) (Gearey et al., 2009; Magny et al., 2009), which too, can be vital in the final archaeological rationale.

The effectiveness of combining high-resolution wetland archaeological evidence with innovative theoretical approaches has been clearly demonstrated by the number of studies carried out in various parts of Europe in the past ten years or so. The life-history approach applied to the Dutch late prehistoric farmsteads, for instance, has shed light on patterns of occupation between wetland and dryland environments, helping to modify biased assumptions on settlement duration, domestic mobility, and cultural continuity (Arnoldussen, 2008*a*; Fokkens and Arnoldussen, 2008; Gerritsen, 2007, 2008) (see also above). Similarly, biographical studies of houses and settlements, combined with 'correspondence analysis' on high-resolution archaeobotanical and archaeozoological data have not only helped reconstruct the diachronic development of some of the Circum-Alpine lake-dwellings (including the various socio-economic factors) (see e.g. Box 6.2), but archaeologists have

also been able to identify households within the village, extending beyond the single house (Doppler et al., 2010, 2011; Ebersbach, 2010*b*). Furthermore, the importance of palaeoenvironmental reconstructions (including climate history) obtained from recent wetland archaeological surveys (e.g. the various projects in the United Kingdom) have also been appreciated by mainstream archaeology in other parts of Europe (Coles and Hall, 1998; Van de Noort, 2001; Van de Noort and Ellis, 2000).

The current situation of wetland archaeological research includes a mixture of integrated and integrating theoretical approaches. This is not only facilitating the reintegration of the discipline into mainstream archaeology, where isolation occurred, but it is also contributing to a more holistic archaeological reasoning, where (re)integration is not an issue. However, the two processes are influenced not only by the different research traditions in the various countries (see Ch. 1), but also by the diversity of wetland ecosystems, which are constantly changing. As a result, an obvious question arises: is the willingness to apply the already existing theoretical approaches enough to face the highly dynamic wetland environment, or should 'new' approaches be developed to achieve a more holistic integration? As discussed in Chapters 5 and 9, the apparent rough yet delicate nature of wetland ecosystems makes them extremely vulnerable against environmental change. One of the major threats to wetland preservation in the past, present and, alas, even more in the future is climate change. Knowing how people coped with climate change in the past will give us some hints as to how to face possible similar threats in the future. Of great help are wetland stratigraphic deposits, as they retain important proxies to study past climate transformations (Magny, 2006) (see also Ch. 6, in particular under 'Palaeoclimatology: Climate Change and Hydrological Imbalances'). A combination of these data with archaeological evidence from both wetland and dryland sites will therefore provide archaeologists with invaluable information as to how people reacted and adapted to climatic variations (Menotti, 2003) (see also Ch. 3 and Box 3.2). A great advantage of palaeoenvironmental studies within wetland contexts is that the data can also be used over fairly large regions that encompass wet as well as dryland ecosystems.

This chapter has highlighted the importance of taking human agency more and more into consideration within general archaeological thought, while trying to avoid analyses that are too processual and environmentally deterministic, which has been the cause of separation between wetland and mainstream archaeology in some countries. However, one has to admit that the high-resolution environmental data obtained from natural as well as archaeological contexts have no parallels in any other non-water-saturated location. This advantage should be exploited as a form of integration of wetland archaeology into mainstream archaeology, rather than allowing it to lead the discipline to further isolation. Such a high availability of environmental data

usable in both wet and dry contexts could, for instance, be used to adapt existing theoretical approaches, or to develop new ones, which are apt to clarify the delicate relationship between people and the environment. While accepting human agency as a crucial variable within the people–nature equation, the significant influence the environment had (and has) on people should also be admitted. We are hereby certainly not advocating a return to a Boasian method of analysis (see Ch. 3, under 'People–Habitat Interaction: Theoretical Perspective'), nor are we trying to find a plausible compromise between the negativity of human intervention supported by cultural ecology, as opposed to historical ecology's more positive attitude towards human action (Balée and Erickson, 2006; Erickson, 2006). Instead, we need to learn how to integrate the various available theories better. The tendency of separating and pigeonholing is particularly pronounced in archaeology (as in various other academic disciplines). This, of course, helps scholars tackle the single problems more systematically. It should be understood, however, that what is being studied (e.g. people–environment interaction) does not allow separations. People and their surroundings are intrinsically inseparable, and they mutually influence each other. It is perfectly acceptable to deconstruct the various elements, but, if one wants to understand the system holistically one should not forget to put the pieces back together again.

In conclusion one can certainly state that the answer to the initial question is of course: theory. No matter how detailed archaeological evidence is, there will be no archaeology without a solid body of theory, and the development of wetland archaeology as an academic discipline is the perfect example. Wetland archaeology is no longer a theory-less subject; the potential of applying existing theoretical approaches, adapting them, and even developing new ones is enormous. All that is needed now is the willingness to do it.

CONCLUSION

Because of their remote and seemingly inhospitable locations, wetland archaeological sites have often been considered as isolated entities in the landscape. Their exceptional level of preservation has, however, revealed that people interacted with those areas much more than previously thought. Ironically, instead of contributing to the general archaeological understanding on a larger scale, wetland sites have turned out to be much more difficult to integrate than their dryland counterparts. As discussed throughout the chapter, this was caused by a number of factors, ranging from a too environmentally deterministic approach, to the total lack of a solid body of theory. This resulted not only in the exclusion of crucial sites from a wider archaeological context, but in

some countries (especially in the Anglophone world) in the complete isolation of wetland archaeology as academic discipline. Despite the initiative of a few prominent scholars urging a prompt integration of the discipline into mainstream archaeology since the 1980s, it has only been in the past ten years or so that a significant restructuring of wetland archaeology occurred. Following Van de Noort and O'Sullivan's publication, *Rethinking wetland archaeology* (2006), a number of archaeologists (including those in countries where wetland archaeology was already part of mainstream archaeology) started to include appropriate theoretical approaches and place more emphasis upon people's identity and their social world. At the same time the multidisciplinary character of the subject has extended its range of influence beyond archaeology. This has not only facilitated a major appreciation of wetland archaeology in general, but it has also started a long-overdue reintegration with the parent discipline in those countries where the division was more pronounced.

As the various examples have demonstrated, processes of integration and reintegration, or simply a better appreciation of wetland archaeology, have certainly started, and positive results are already part of the rich archaeological literature. We have certainly learnt that no matter how detailed archaeological evidence is, it cannot be considered in isolation. The uniqueness of single individuals or cultural groups can only be appreciated when placed in a proper and wider social and geographic context.

9

Awareness and Protection of Wetland Cultural Heritage

INTRODUCTION

The apparent scission between wetland archaeological research and mainstream archaeology discussed in Chapter 8 has sometimes had negative repercussions on the relationship between the discipline and the general public. The excess of emphasis placed upon scientific explanations has made it more difficult for laypeople to appreciate the real value of wetland archaeology. This is certainly not due to people's lack of interest in the discipline, but to the discipline's failure to communicate with the public. Scholars are often reluctant to use more simplistic or indeed 'romantic' explanations, arguing that this diminishes the importance of the topic. A typical example is that of the lake-dwelling phenomenon in the Circum-Alpine region, where people's positive response to the first lake-dwelling discovery in the nineteenth century was not due to the skilful way in which scholars presented the event to the public, but rather to the romantic image that was developed around the discovery. As scientific analysis began to be included in the archaeological process, scholars became less willing to divulge their results publicly (especially during the development of 'New Archaeology'), and the gap between academia and the general public widened. Only recently has it been realized that this separation was causing serious problems to both sides (academia and society), and something had to be done (Sommer, 2002). The first part of this chapter explores the process of 'reconciliation' in various steps; from the creation of more popular archaeology magazines and books, to involving people directly with workshops, and/or 'hands-on' archaeology sessions (Leuzinger, 2004). Museums were the first to take the initiative to involve the public more actively. Thanks to the new methods and more affordable costs of conserving the delicate waterlogged artefacts (see Ch. 5), more and more exhibitions focused on wetland archaeological remains. The excavation of sometimes complete habitations inspired the idea of reconstructing full-size houses or villages (in some cases even *in situ*) after the excavation was completed, subsequently to

become open-air museums (see the Pfahlbaumuseum of Unteruhldingen, Germany, Biskupin in Poland, Ledro in Italy, Āraiši in Latvia, Lake Feder in Germany, and many more). With the exception of Japan (the Shikoku Mura), the majority of wetland open-air museums are to be found in Europe. However, a large number of museums throughout the world have a rich wetland archaeology artefact collection; see, for instance, the Museum of Anthropology at the University of British Columbia, Vancouver; the Makah Museum, Olympic Peninsula, Washington State, US (with the famous Ozette site materials); the Brevard Museum of History and Natural Science, Cocoa, Florida, US (with some replicated artefacts of the Windover underwater cemetery); and the Museum of New Zealand *Te Papa Tongarewa*, Wellington. Finally, this part discusses the various strategies developed (or being developed) by the various museums to inform the public in an interesting and attractive way, without losing the scientific aspect of the topic discussed.

The second part of the chapter deals with wetland management policies and how we preserve our cultural heritage. Wetlands are a unique source of archaeological resource, which is particularly delicate and vulnerable to change. A minor variation in climatic conditions may affect their hydrological balance, damage their ecosystem, and compromise their existence. How much and in what ways, wetlands are affected depends upon a variety of factors, which are mostly linked to the wetlands' geological and morphological structure, latitudinal location, vegetation and hydrology of their catchment area, and, finally, human presence. Blaming the climate exclusively for any alterations in the wetlands (past and present) is no longer an option. The consequences of an initial variation in climate are often accentuated by human reactions to that change (see also Ch. 3). Human influence on the environment can also be intentional and have nothing to do with climate whatsoever.

Integrated strategies have to be devoted to preventing the ongoing degradation that could lead to a total loss of our wetland cultural heritage. However, it is important to realize that preservation of historical environment is not about preventing change, but managing it. Another important point is to focus not only on preservation of individual monuments or sites, but to take a broader approach, using landscape characterization (Corfield, 1998; Olivier, 2004). It is therefore crucial to understand the historical environment and to untangle the complexity of wetland histories in order to develop suitable strategies of management and protection. This chapter shows how different local authorities in various countries have developed a range of approaches to face the threat. See, for example, English Heritage, UK; the New Zealand Resource Management Act 1991 (and the various local preservation programmes such as the Bay of Plenty Regional Council and the Te Ture Whenua Maori Act 1993); the 1952 Law in Japan; the United States Environmental Protection Agency; the National Cultural Heritage Agency in Denmark; the Service Régional des Monuments Historique in France; and the Landesamt für

Denkmalpflege Baden, Baden-Württemberg, and the NABU-Naturschutzzentrum in Germany, to mention but a few (Adamus and Brandt, 1990; Coles, 1995, 2004; Coles and Olivier, 2001; Fischer et al., 2004; Matthiesen et al., 2004). It is, furthermore, interesting to note that local and national programmes have triggered larger heritage management initiatives such as the European Archaeological Council (EAC). A final goal of this chapter is to address and encourage a series of objectives in order to facilitate our understanding of environmental relations (especially linked to endangered habitats), promoting recognition of cultural heritage identity, disseminating the best practice in scientific investigation, and, most importantly, providing a common scientific framework for cooperation between scholars and the various worldwide research organizations.

INTERFACING ACADEMIC RESEARCH AND PUBLIC EXPECTATIONS

It is believed that the highly scientific orientation of wetland archaeological research has not only isolated the discipline itself from mainstream archaeology, but has also hindered its relationship with the public. However, the recent establishment of a number of open-air museums linked to wetland sites contradicts this assumption. The remarkable quantity and quality of well-preserved organic material, ranging from houses to a large variety of artefacts, tools and weaponry have stimulated the public's interest and facilitated the development of new didactical initiatives. Notwithstanding this positive response from the public, scepticism has been expressed by the academic community regarding innovative but rather unorthodox pedagogical methods of interaction. Museums (open-air museums in particular) linked to hands-on archaeology initiatives have been accused of adopting too simplistic a way of presenting archaeological results to the public, with the danger of creating an alternative image of the present rather than an 'objective' view of the past. In other words, we (as archaeologists) fail to 'transport' people to the past, importing instead a distorted past into the present (Pétrequin, 2008). As an alternative, it would be more sensible to establish a relationship between the past and the present, whereby people visiting a museum are not simply educated but can engage directly with the past (J. Thomas, 2004).

Experts of various disciplines tend to create impenetrable worlds around themselves and their fields of expertise, often underestimating the willingness of laypeople to explore those worlds. The main problem is that they (experts and laypeople alike) speak 'different languages', hence common ground and apparent congruencies are overlooked and discarded from the start. Experts

often fail to communicate with the public, with the excuse of having different and uncompromisable expectations. This is unfortunate, because people are willing to know, and to engage with the past more actively. Communication barriers can certainly be overcome; all that is needed is the willingness to do it. Three of the most effective avenues that archaeologists can use to communicate with the public are, (*a*) literature (books, journals, magazines, catalogues, etc.), (*b*) media (newspapers, television, cinema, and the internet—which nowadays covers all the avenues anyway), and (*c*) museums, with a special emphasis on open-air museums. The latter avenue, in particular, plays a crucial role, as it is closely linked to pedagogical activities involving schools and other educational institutions. Positive communication initiatives are, however, not achieved by single strategies working in isolation, but the result of the synergetic efforts of all of the above.

Popular vs. Scientific Literature

There are many reasons why the relatively high number of specialized archaeology journals and books seldom expand their readership beyond academic boundaries. Although the esoteric jargon might be one reason, the inaccessibility to academic publications seems to result from an intentional reluctance by scholars to involve the external world in a too-highly specialized archaeological enclave. Is the fear of involving the public justified by the fact that over-simplistic explanations may lead to misunderstandings and/or misinterpretations of the results, or is it because it is actually difficult to simplify seemingly complex issues? Both reasons may be true, but the main problem resides once again within academia itself. As is demonstrated by the number of popular archaeology magazines (e.g. *Current Archaeology*, *Archäologie Schweiz*, *Archeologia*, etc.), scholars do make the effort sometimes, but this effort is not appreciated within the academic world, where such publications are rarely considered relevant to the discipline. As a result, archaeologists (especially in academia) tend to avoid these publications, once again at the expense of the public. This is such a pity, because simplicity does not necessarily mean lack of information. In fact, thanks to their higher financial availability, these magazines allow attractive colour images and diagrams that, conversely, cannot be included in academic journals. If artfully used, these images can provide additional information, hence compensating for scientific aspects that have been intentionally left out of the text. Similar problems are also encountered with books, both edited volumes and monographs. On the other hand, a good example of publications regarded to be a fairly successful interface between public and academia are catalogues that accompany museum exhibitions. They are colourful, informative, easily accessible, and in some countries are regarded as fairly prestigious publications.

The Media Influence

The apparent isolation of wetland archaeology within the academic world is definitely not mirrored by the media. Discoveries of remarkably well-preserved artefacts are often mentioned in newspapers, television news, and documentaries. An example is the British TV series *Time Team*, in which wetland archaeology projects and excavations such as Flag Fen, the Goldcliff Mesolithic human footprints, and Seahenge have often appeared. These cases are also indirectly linked to a much larger entertainment network (in film and other media, the characters Indiana Jones, Lara Croft, etc.), capable of capturing the attention of a large audience in contemporary popular culture (Holtorf, 2007). Archaeology is also part of the so-called 'living history' television programmes, which attempt to portray functional past living conditions supported by historical (and archaeological) research. Such a trend started with the *1900 House* programme made by Channel Four in 1999, which was followed by similar examples such as the *Frontier House* in the American West, and the *Abenteuer Mittelalter—Leben im 15. Jahrhundert* (Middle Ages adventure—life in the fifteenth century), shown in Germany by ARTE/ARD Channels in 2005. More recently, even the prehistoric lacustrine villages of the Circum-Alpine region have been taken into account for such projects. Two of the most famous ones are the *Steinzeit—Das Experiment* (Stone Age—the Experiment), produced by the German TV station SWR/ARD on Lake Constance in the summer 2006 (Schlenker and Bick, 2007), and the Swiss version entitled *Pfahlbauer von Pfyn* (Pile-Dwellers from Pfyn) created by the SF broadcasting team in the summer of 2007 (Leuzinger, 2008). Almost thirteen million viewers watched the four 45-minute films produced by the German channel, and more than half a million people tuned in when the Swiss programme was aired live (for about 15 minutes) every night. It was a big success in both cases. However, the infrastructures constructed for the programme were often criticized by archaeologists as being an alternative representation of the present, in an artificial prehistoric setting. Despite the entire work being supervised by leading experts, and the set (houses, material culture, etc.) having been created as closely as possible to archaeological evidence, the intention of the organizers was never that of reproducing prehistory. The main purpose was to make people aware of the existence of such settlements, their importance concerning people's cultural heritage, the scientific research being carried out to study them, and, most importantly, the urgent need to protect them (or what is left of them). The programme had nothing to do with finding out how people lived in the past, and in fact, it is still not known (and probably never will be) whether the Neolithic lake-dwellers were entirely happy to live in such seemingly inhospitable environments. What is known for sure is that the programme left a significant impression on

the public; people still remember those programmes after more than three years, and their attitude towards the lake-dwellings has changed considerably when they visit museums (see below). It may not be a direct consequence of it, but the public is now more interested in finding out what really happened in the Neolithic lacustrine villages, and as a result, they make more effort to obtain that information.

Open-Air Museums: Visitors Always Come First!

As discussed above, the discoveries of archaeological material found in waterlogged contexts are often mentioned in newspapers and TV programmes. However, once the excitement of the discovery subsides, the presence of the artefacts in traditional museums no longer captures public attention. This is probably due to those objects' lack of monumentality, or possibly to the fact that the majority of these are mundane objects, which, once they are taken out of their original context, lose importance and fascination. Although not fundamentally proved, this theory is supported by the number of successfully established open-air museums all over Europe and beyond (e.g. Japan), which promote the replication of those objects and their original setting (e.g. houses), following real archaeological evidence. The idea of open-air museums created on archaeological evidence of well-preserved dwellings was inspired by the first folk museum, built in Skansen (Sweden—1891), at the end of the nineteenth century, followed by Lyngby (Denmark—1901), the Kashubian Ethnographic Park (Poland—1906), and Arnhem (the Netherlands—1912), at the beginning of the twentieth century (Rentzhog, 2007). The buildings of all the above-mentioned open-air folk museums were not replicas, but original translocated habitations of prehistoric times. Drawing from this concept of 'living history', the well-preserved remains of prehistoric wooden dwellings found in waterlogged conditions inspired archaeologists to replicate them, including the associated artefacts (Schöbel, 2004*b*). From the first established examples of open-air archaeological museums (e.g. Lindau (1910–22), Kammer (1910–22), Seengen-Riesi (1925), and Unteruhldingen (1922–31)) (Schöbel, 2004*a*), there are today more than two hundred such institutions scattered around Europe, with some of the best known being Lejre (Denmark), the Pfahbaumuseum (Lake Constance, Germany), the Federseemuseum (Lake Feder, Germany), the Glastonbury Peat Moors Centre (England), Flag Fen (England), the Scottish Crannog Centre (Kenmore, Scotland), the Latenium Museum, Wauwiler Moos Centre and Gletterens Village (Switzerland), Āraiši (Latvia), Biskupin (Poland), and Montale (Italy), to mention but a few (Pelillo, 2009; Schöbel, 2006*b*).

What makes open-air museums so successful and attractive? There are a number of reasons, but most important is their pedagogical character linked to

the first-hand experience concept of learning. Not only are visitors fully immersed in a past-like environment (e.g. the full-size ancient house replica), but, with the 'hands-on' concept, they can become part of the setting, experiencing, for instance, how to reproduce different artefacts using ancient technologies (Carstensen et al., 2008). Despite the fact that it is clearly stated that those reproductions (house structures and artefacts) are not meant to be exact replicas of ancient original counterparts, open-air museums are often criticized by the academic community as being 'fake', or simply a means of entertainment, which may mislead the public. This is certainly not true, for they have to fulfil standard criteria of archaeological and pedagogical quality, even before being constructed (Hooper-Greenhill, 2007). In all cases, scientific explanations are provided alongside the practical (hands-on archaeology), and people are well informed about the real archaeological evidence, which in most cases is also exhibited in different sectors of the museum. It is made specifically clear to visitors that the main goal of the hands-on approach in open-air museums is not that of recreating the past, but that of questioning and remembering it (Duisberg, 2008; Lord, 2007; Saraydar, 2008; Schmidt, 2000; Schöbel, 2004*b*).

Perceptions of (Re)constructed Pasts

One of the main objectives of open-air museums is to adapt to people's demands. Learning processes change from person to person and depend on age, culture, and educational background. Pedagogical institutions such as open-air museums should be able to understand the responses of visitors and modify display techniques and teaching methodologies accordingly, without compromising the scientific character of whatever is taught. Visitors often bring a myriad of ideas to the museums, including their own conceptions of the past. It is by establishing a direct interaction with the displayed material and the scientific information provided that the past is questioned and continually recontextualized, rather than artificially reconstructed (Copeland, 2006). It is therefore important that museums recognize people's different ways of assimilating information, while at the same time constantly questioning the effectiveness of the displayed material and teaching methodologies (Schadla-Hall, 2004).

Guided tours and over-descriptive written information may lead to dangerous indoctrination, leaving less space for a visitor's personal (re)interpretations (Howard, 2003). A balance should be established between providing adequate information (in order to avoid confusion and misunderstanding) and not overloading the site (and the visitors) with too much material. This is not an easy task, since such a balance varies according to the visitors' ages, education, and culture. As a result, the permanent descriptive material in the museum should be as neutral as possible, providing additional information

with tailor-made guided tours, possibly following the above-mentioned criteria. When preparing a guided exhibition, one aspect that has to be taken into account is the threat of a complete detachment from scientific approaches. Although people may be more interested in the results of archaeology rather than the process of obtaining them (McAdam, 1999), giving the visitors access to the intellectual tools used to create archaeological knowledge may give them the power and ability to elaborate personal interpretations constructively. Today's museum visitors prefer to be challenged; in addition to having a pleasant day out, they want to know more about the archaeological site(s). Not only would this help with assimilating the information, but what is learnt will be remembered for longer. People like to engage with archaeological material, and touch it (if possible), but most importantly they need space (physical and intellectual) to be able to experience themselves as part of the display and/or the reconstruction (Collins, 2008). Touching a millennia-old wooden structure, understanding the ancient technology used to make it, and maybe even being part of the reconstruction process (e.g. the hands-on experience), will leave an indelible impression on people. At the same time though, they will want to know how the archaeologists recovered the artefacts and established their chronological date. Therefore, information (in the form of videos and/or written boards) about the scientific aspects of archaeology is vital to trigger a more holistic participation. To facilitate this, some museums organize short open-day visits to nearby excavations. A one-to-one interaction is beneficial to both the public and the archaeologists. While it gives visitors the opportunity to see and ask about what in the museum is usually 'hidden', it also provides immediate feedback for the archaeologists; fresh inputs from 'outside' may indeed serve to avoid biased assumptions. In this case, the interpretation of archaeology also develops an informative aspect—by seeing what archaeologist do, a narrative is created, and this may signify the 'past in the present'; in other words, an integration of ancient culture(s) and contemporary archaeological research (Pearson and Shanks, 2001). It is the whole of this process that helps bridge the gap between original artefacts, the procedures that retrieve them (excavation and scientific analysis), and the creation of replicas. These reconstructions therefore become essential for people (museums visitors) to 'access' the past.

An ultimate challenge for open-air museums is to communicate with visitors more holistically, in order to question the effectiveness of how archaeological materials are shown to them. Museum pedagogy is an extremely dynamic discipline that requires constant modification and adaptation. It has to be understood, however, that this evolving process does not follow a 'one-way direction', but it can only be implemented through synergetic interaction and collaboration between experts and visitors. Both sides should accept that what is effective now may not be tomorrow, and vice versa.

SAFEGUARDING WETLANDS' ARCHAEOLOGICAL HERITAGE

The particularly fruitful nature of waterlogged deposits in yielding remarkable archaeological evidence may be an advantage to bridge the gap between academic research and the public. What is not often discussed, however, is that these delicate environments are constantly threatened by natural as well as human influence, which jeopardize their existence. The fact that waterlogged archaeological remains are difficult to locate complicates the enforcement of protective measures even further. Some of the major threats are, for instance, the lowering of the water-table, water abstraction for domestic, industrial, and agricultural use, erosion, desiccation (caused either by human activity or climate change), and different kinds of pollution (water, soil chemistry, etc.). Although we tend to separate natural from human-induced causes, the two are intrinsically interwoven and can affect each other in a dangerous, chain-reaction. Mitigation of direct impact on buried archaeological remains is often hampered by our lack of knowledge about exactly how much there is. This not only reduces the possibility of identifying their precise location, but also their state of preservation (see Ch. 5). Despite the scientific advances in tackling these problems, there is still much uncertainty as to what type of action should be taken to assure proper protection. This is usually due to the complexity of localized conditions, which are linked to a much wider hydrologic context. As a result, heritage managers are often faced with the dilemma of the choice between *in situ* preservation and excavation (both of which are expensive and time-consuming solutions) (Coles, 1995; Coles and Olivier, 2001; Corfield, 2007). Whatever the solution might be, it is now clearly understood that it cannot be found within the archaeology community only; more collaboration should be established with those who are responsible for wetland management and, most importantly, with the general public. It is, after all, people's cultural heritage that we are dealing with.

Research initiatives with the goal of understanding the wetlands better have been developed more regularly in the past four decades. In the United Kingdom, four major wetland surveys were carried out between 1973 and 2001: the Somerset Levels Project, the Fenland Survey, the North West Wetland Survey, and the Humber Wetland Project (B. J. Coles, 2001; Coles and Orme, 1980; Cowell and Innes, 1994; Hall and Coles, 1994*a*; Lane and Coles, 2002; Van de Noort, 2004*a*; Van de Noort and Ellis, 2000). These were followed by other projects, such as those of the Irish Archaeological Wetland Unit (IAWU) and the Discovery Programme in Ireland in the 1990s (Fredengren, 2002; O'Sullivan, 1998; O'Sullivan and Daly, 1999; Raftery, 1996*c*), and two Scottish projects (the South-West Scotland Crannog Survey

and the Moine Mhór Cultural Heritage Project), both initiated by the Scottish Wetland Archaeology Programme (SWAP) from 2002 onwards (Henderson, 2004, 2007*b*). All these surveys have certainly contributed to increasing our knowledge and stimulating the public's interest in the wetlands. People and the academic community have become more aware of the importance of protecting the wetlands in order to safeguard the invaluable cultural heritage buried within them. However, awareness and knowledge are not always enough: systematic management strategies and adequate policies are needed to implement them. Most importantly, the value of a constructive dialogue between archaeologists and nature conservationists has been recognized. A milestone of this achievement was Bryony Coles's publication, *Wetland Management* (Coles, 1995), whose purpose was to suggest a range of existing management techniques that could be applied within different archaeological contexts to enhance the preservation of waterlogged archaeological remains. It was thanks to this survey that English Heritage was able to develop one of the most effective strategies for wetland management in Europe (English Heritage, 2002, 2008; Olivier and Van de Noort, 2002). The strategy follows three broad principles: (*a*) the development of collaborative partnership with all bodies interested in the management of the wetlands, (*b*) the encompassment of entire wetland areas rather than individual sites, and (c) the promotion of better access to the wetlands, as well as their conservation. The four main components (management strategies, policies and procedures, education and outreach, and research and understanding) have been strategically planned to target key priorities such as the identification of the most important monuments at risk, the building of research strategies to develop wetland-specific survey techniques, the development and improvement of *in situ* preservation, the initiation of synergetic collaborations with national and international agencies actively involved in wetland management, and the growth of understanding of the cause of the major threats to wetland environments. Some of the key factors to achieve these priorities are, for instance, to promote mechanisms to integrate cultural heritage and natural conservation values in wetland management (e.g. creation of inventories of primary wetland sites and the development of pilot 'beacon sites' as platforms for inter-agency cooperation); to raise awareness of the value of wetland cultural heritage; to promote cultural heritage interest in wetlands in the work of local authorities, as well as of national and international agencies (e.g. constant change and adaptation of legislation, policies, and planning regulations); and finally, to ensure the development of coherent research strategies (e.g. systematically planned surveys, excavations, and scientific analysis) (Olivier, 2004: 161–3). One of the major achievements of this systematically planned and effective strategy so far is the expansion of the focus of attention to wider archaeological perspectives, from site-dominated approaches to viewing the broader landscape (also taking people into account together with their current economic

and social relationships). Wetland environments should be protected as a whole, basing the strategic management decisions upon an assessment of all the relative values involved, and not just on the importance of the cultural heritage itself. The wellbeing of the entire community (large environments) is more important than that of single individuals (specific sites). It must be accepted that sometime sacrifices have to be made at the expense of less prioritized issues in order to achieve wider objectives. A special feature that has emerged from all this reconsideration of priorities is the reorientation of existing orthodoxies of protection towards more flexible approaches, which are compatible with more prevailing attitudes to sustainability and environmental change. In other words, management solutions should be appropriate for particular changes and evolving circumstances (see the Groningen Project, below). It is important to acknowledge that not all aspects are of the same value; judgements on the character and significance of what should (or should not) be protected are vital, and need be made within a sphere of wider communal interest that goes beyond archaeology and cultural heritage (M. Cox, 1995; Denny, 1995). However, this is only achievable if all parties involved in wetland management clearly highlight their different objectives and interests. A reconciliation of the various differences in relation to the diverse priorities will then lead to successful strategies and positive results. Finally, successful wetland management is also based upon international policies. Therefore, in addition to being part of the already well-established Ramsar Convention on wetlands (Iran, 1971), one major step in the direction of cross-border strategic management planning was taken with the establishment of the European Archaeological Council (EAC) (see below).

The Ramsar Convention

The Ramsar Convention (www.ramsar.org) established in 1971, recognizes the cultural values of the wetlands, promoting their sensible use and conservation in 160 countries (June 2011) worldwide. The 'wise use' concept was created in particular as an integrative approach to identify and resolve potential conflicts between different uses of wetland resources, with the main goal of designing and implementing appropriate and effective management strategies. In addition to the more general nature-oriented priorities, the 'wise use' approach also emphasizes cultural values (Ramsar, 2007). However, despite this being an advantage for heritage managers, it also means adapting to much broader environmental concerns, as those of the Convention (Joosten, 2003*a*, *b*). A close collaboration with the EAC has led to the recognition of weaknesses in valuing and protecting cultural heritage within the wetland, which causes gaps in the general definition and implementation of related policies. It has, however, been agreed that if a wetland contains significant cultural values in

addition to ecological ones it should be considered of international importance within the Ramsar context. Contracting parties are therefore encouraged to include those cultural values, if they are identified (Ramsar, 2002, 2005); and the latest Ramsar strategy plan 2009–15 (Ramsar, 2008), has been structured with the intent of increasing the recognition of cultural heritage values, and incorporating them more successfully into decision-making management policies. The *Culture and Wetlands* guidance (Papayannis and Pritchard, 2008) clearly identifies the importance of synergetic collaboration between the various bodies responsible for implementing the Ramsar Convention, and those organizations more concerned with cultural issues. The guidance mentions in particular the strategic importance of the Wetland Archaeological Research Project (WARP), the EAC, and the International Committee on Archaeological Heritage Management (ICAHM).

A European Outlook and the European Archaeological Council (EAC)

Despite the willingness to move towards an integrated international orientation of wetland management and the various efforts to fulfil it (see the Ramsar Convention above; and the EAC below), the various European countries still have different approaches and different policies as to how to handle cultural heritage issues within wetland environments. These differences depend on a number of factors, ranging from different research traditions and cultural values to the endemic significance of the single wetland areas. It is clear, though, that some of these problems are ubiquitous, and can be found in almost every European country where wetlands are present. A typical example is the effect of pollution on buried waterlogged archaeological remains, coming from either rainfall or contaminated water from nearby environments. Other aspects of wetland management are more localized, and in some countries they are more accentuated than in others. For example, an absence of political control over wetland operations (resulting in a lack of policies concerning cultural heritage) is more noticed in Italy, Sweden, Poland, and Finland (Brzezinski, 2001; Marzatico, 2001; Taavitsainen, 2001). Conversely, examples of very efficient and successful ways of monitoring and preserving wetland environments with rich cultural heritage are found in the coastal areas of the Netherlands and northern Germany, especially concerning the terps (*Wurten*; prehistoric and historic raised settlements located in previously flooded areas). All these monuments are strictly protected by legislation, extensive surveys are periodically carried out to check the state of preservation, and in most cases over-building, linked to development, is refused. In some countries more that others (e.g. Poland, Ireland, and, up to about the year 2000, Switzerland) wetland cultural heritage is also threatened by the so-called

'development' (road constructions, industry, etc.) (Brzezinski, 2001; B. J. Coles, 2001; Ramseyer, 2001). The problem concerning long-term permissions to drain or quarry wetland areas, that cannot be withdrawn or overruled by present legislation, is paradoxically more prominent in countries, such as the Netherlands and Britain, where some of the best management and protection strategies have been developed (Marsden, 2001; Walters, 2001). The difficulty in surveying and detecting archaeological remains in waterlogged contexts has been tackled quite effectively by some countries, such as England, the Netherlands, Denmark, and Germany. However, the problem of inadequate information on the various wetland characteristics still persists in other countries, namely Greece, Italy, Norway, Russia, and a number of countries in the eastern Baltic Sea region. Notwithstanding this uneven situation, European Member States are prepared and willing to develop international agreements on legislations to ensure proper consideration and protection of wetland cultural heritage.

The European Archaeological Council (EAC)

Urban development, official policies on agriculture, and planning processes are vital and strictly linked to heritage management. The influence of cross-border development in a growing European Union is affecting all the member states, in a more and more similar way. Within this pan-European context, mutual concern about the legal management of archaeological heritage has been expressed by a number of countries, feeling the need for effective international legislations and cooperation mechanisms to ensure proper, Europe-wide attention to and protection of the wetland cultural heritage. After a series of international meetings, in October 1999 the statutes of the European Archaeological Council were approved by royal decree under Belgian Law, and on 25 November of the same year the new not-for-profit organization was publicly inaugurated at the offices of the Council of Europe in Strasbourg (Olivier, 2001). The primary purpose of the EAC is to provide a forum for archaeological heritage management organizations in order to establish more structured cooperation. In addition the EAC acts as interlocutor towards common aims, by monitoring and advising on various issues concerning the management of the wetland archaeological heritage. It furthermore promotes scientific research, publications, and general communication with the public within the context of archaeological heritage in Europe. The advantage of such an organization is that it can provide a single coordinated voice to speak out on specific issues. It can, for instance, influence the development of pan-European policies in order to ensure proper awareness of their importance and impact. At the same time it serves as an interface between academic research and the general public by highlighting the importance of involving people and communities (see below) in the general process

of managing the wetland cultural heritage (Olivier, 2001). An effective collaboration at international level not only facilitates the development of more systematic management strategies, but also endorses the integration and coordination of legislative provisions intended to protect the heritage management of the wetlands in general. Lack of understanding of how protective measures relate to each other may have serious consequences and lead to the failure of the enforcement and implementation of those measures (see e.g. the Lappel Bank case in England) (Marsden, 2001: 10).

A Worldwide View

The inexorable disappearance of wetland environments, with the consequent loss of cultural heritage is not limited to Europe but is a worldwide phenomenon. For instance, of the 86 million acres of wetland present in the United States in 1700, less that half remained at the end of the last century (Nicholas, 2001: 267). Protecting what is left has therefore become a major concern in a large number of countries all over the world. However, despite the fact that protective legislations for cultural heritage exist almost everywhere, none of these are specifically designed for the wetlands. This, of course, does not necessarily mean that these fail to provide protection to the cultural heritage once the archaeological remains are identified. The main concern is, as stressed above, the inconsiderate destruction of natural wetland environments with potentially rich cultural heritage, which, alas, have not as yet been properly identified. An even larger problem concerns privately owned land, which in some countries is not protected by regional or national legislation. In the United States, for instance, the protection of archaeological resources enforced by the Archaeological Resources Protection Act (1979) is not effective on private property (Nicholas, 2001). Similar issues are present in New Zealand, where, too, sites on private land (therefore not under the government's Resource Management Act of 1991), are the responsibility of the landowners. However, with sympathetic owners, there are other ways of enforcing wetland protection. In the Auckland region, for example, there is the ARC Environmental Initiatives Fund, or the New Zealand Landcare Trust (Gumbley et al., 2005: 33). The protection of sites on public land is more straightforward, but they have first to be listed in plans under the Resource Management Act (RMA), and/or the Historic Places Act (HPA) (1993). In Canada, cultural resources are protected by provincial mandate. In British Columbia, for instance, all archaeological sites (on private and public land) are, in theory, protected by the Heritage Act of British Columbia (HABC). However, many exceptions can occur at the legislation level, and in some cases the Municipal Act can override the HABC legislation (Nicholas, 2001: 268). Japan is yet another example where, despite people's strong respect for cultural

heritage, it is almost impossible to preserve archaeological sites by stopping the development system. However, nothing is neglected, and the developers themselves are personally involved in the rescue operations, even if they do not have to be. In fact, although the 1952 law for protection of cultural properties does not state that the developers should take responsibility for all the archaeological excavation expenses involved in their operations, they always do. Similarly, when archaeological sites are discovered during small private operations or agricultural activity, it is the Japanese government that funds them (Matsui, 1992). In all cases, all archaeological remains are taken care of in the best possible way. This pro-development respect for cultural heritage is, in a way, what is meant by 'wider communal interest' (discussed above), whereby sacrifices are to be made by all parties engaged in the policy-making sphere of cultural heritage management, in order to achieve the maximum well-being of the society as a whole.

Protective Scheme Implementations: Successful Initiatives

As argued in the previous sections of the chapter, successful management strategies for *in situ* preservation of wetland archaeological sites depend on myriad of factors, ranging from legislative policies to the physical attributes of the sites (morphology, hydrology, soil chemistry, etc.), including 'external' natural and cultural influences. Even if all these aspects are positively combined, there are always unexpected variables that may interfere with the preservation process. Notwithstanding all these difficulties, there are a few examples where *in situ* preservation of rather large areas has been fairly successful.

Anti-erosion Measures on the Circum-Alpine Region's Lakes

Rather than desiccation due to drainage activity, one of the major threats to the prehistoric lacustrine village remains within the Circum-Alpine region is erosion. This particular threat, as with all the others, is a combination of natural and cultural factors triggered within and beyond the lacustrine catchment area(s). Although as lethal as drainage, erosion is easier to tackle if the location of the site(s) is known. Especially in the northern parts of the Alps (Switzerland, eastern France, and southern Germany), there are quite a few lacustrine underwater sites that have been (and are being) damaged by erosion processes. After more that four decades of intense salvage excavations, preservation strategies are now prioritized, and a number of successful anti-erosion projects have been carried out in the past ten years. Some of the best examples are the submerged lacustrine settlements of Bodman-Schachen 1, Nussdorf-Strandbad, Hornstaad-Hörle I and II, Wangen-Hinterhorn in Germany, and

Ermatingen in Switzerland, all on Lake Constance (Brem, 2006; Köninger and Schlichtherle, 2006), and the site of Sutz-Lattrigen-Hauptstation, on Lake Biel (Switzerland) (Hafner, 2005, 2006; Hafner et al., 2006) (see also Ch. 5). An example of anti-erosion measures that differs from the above-mentioned ones is that of Lake Chalain, France.

Protecting Lake Chalain's Cultural Heritage: A Mix of Political, Environmental, and Public Issues

By the 1980s, it became apparent that the numerous prehistoric lacustrine village remains on Lake Chalain were in peril. Lake level fluctuations caused by over-exploitation of water for hydroelectric and agricultural purposes started to erode the sediments where the archaeological remains were buried (Pétrequin, 2001). After an agreement with the hydroelectric company in 1986, the area was fenced off, denying access to people, especially holidaymakers, who would have been prone to damage the archaeologically rich sediments. In 1992, legal protection was enforced and a year later practical anti-erosion measures (bags of clayed soil, geo-textiles, and vegetation replanting) started. Lack of maintenance of the area created a series of problems with the community council and the local people, who blamed the archaeologists for disrupting tourism in the area. Meanwhile, the planted vegetation grew rapidly (Pétrequin, 2001, 2006). At that stage the project seemed to have developed a two-sided aspect: (*a*) an unhappy local community, mirrored by archaeologists disappointed by the poor response of the public to the initiative; and (*b*) a rich, reinvigorated vegetation, which did indeed diminish the erosion. More funding obtained after the year 2000 brought new interest in the area, and encouraged renegotiations with the local authorities with the intention of learning from previous mistakes. The initial stage of the Chalain cultural heritage protection project is a typical example of the enormous difficulties and variables present in wetland management, when parties involved are unwilling to compromise on their priorities.

More than High Water-Tables

The major concern for cultural heritage waterlogged remains in peatbog environments is the continuous lowering of the groundwater tables in order to claim more land for agricultural and developmental use. However, keeping the archaeological organic remains wet does not seem to be the only concern. Successful protection strategies also include constant adaptation to sustainable preservation (see the Groningen Project, below). Active interaction with the local communities, policy-makers, and landowners is to a certain extent more important in the long run if we want those protective measures to work (see Lake Chalain, above).

The Federsee: Shrinking in Size, Expanding in Popularity

After more that 60 years of research (1920s to mid 1980s) it was realized that the numerous prehistoric sites discovered in the constantly shrinking Lake Feder basin (Germany) suffered serious damage due to the increased level of desiccation. As a result the State Archaeological Service (previously called *Landesdenkmalamt Baden-Württemberg,* now *Landesamt für Denkmalpflege Baden-Württemberg*) started to coordinate efforts to reduce this threat (Schlichtherle, 2001; Schlichtherle and Strobel, 1999). A series of meetings with various organizations as well as local authorities and landowners were organized to discussed strategic wetland and cultural heritage preservation plans. With the support of the Finance Ministry and the State Lottery it was decided to buy any plot of land (whether or not included in the protection area) that came up for sale. A strategic advantage of this operation was that the sales were initiated by the landowners, not by conservation groups and/or archaeologists. A subsequent cunning move, initiated by the conservation groups, was that of exchanging arable fields and meadows within and around the protection zone for land within the core areas of archaeological and nature-conservation interest (Schlichtherle, 2001). This turned out to be an excellent strategy, since farmers who did not want to sell the land for money but wanted to continue farming, had the option of doing so by swapping parcels of land they owned in the archaeology/nature conservation areas for the same acreage just outside. Another particularly successful strategic initiative was that of combining the natural wetland habitat with an open-air museum, based on the archaeological finds. It was this carefully planned synergetic effort of various groups interested in the area, working together without hindering each other, that laid the foundations for a successful protection scheme of both cultural and natural wetland heritage. Although lessons have certainly been learned from the examples of Lake Chalain and the Federsee, dessication and erosion are still very much threatening the lake-dwelling cultural heritage of the Circum-Alpine region. Since these prehistoric lacustrine settlements have recently (27 June 2011) been added to the UNESCO World Heritage list, a solution to the problem is all the more urgent now, if we do not want to lose them forever.

The Åmose Peatbog: Once Wet, Now Re-wetted

In the mid 1980s, following two centuries of peat extraction and drainage, the significantly reduced yet still extremely important archaeological remains of the Åmose peatbog (western Zealand, Denmark) were facing new threats, resulting from the intensified agricultural activity in the area. After assessing the situation, the Danish Forest and the Nature Agency concluded that protective measures had to be taken urgently to avoid further destruction of the invaluable cultural heritage. Instead of protecting single sites separately it

was decided to adopt the 'area approach', whereby a higher water-table within the entire perimeter of the peatbog would assure better longer-term preservation of both natural and cultural heritage. A series of legal discussions resulted in the decision to create a national reserve (the Kongemose Reserve). The land was then bought and put through a re-wetting programme, creating 230 ha of protected peatland. The prompt success of the initiative encouraged the authorities (and the local community) to expand the protected zone to encompass more archaeologically rich areas, at the same time creating a wider range of low-intensity recreational activities (Fischer, 1999, 2001). An ambitious project to create an 8000-hectare nature reserve was initiated in 2001, but a change in the Danish political situation at the time hindered its development. However, the positive response of local communities continued to promote the initiative, as a recent intensification of agricultural activity brought new concern about cultural heritage management issues. Meanwhile, the paradox is that the archaeological rescue operations carried out in the Åmose bog area have increased recently, and the costs may, in the long run, exceed the price of buying all the fields that need protection (Fischer et al., 2004). However, the attitude of preserving rather than excavating archaeological remains in the Åmose peatbog area is very much encouraged; all that is needed is more effective local and national management strategies, which also include more international influential legislation.

The Groningen Project: Eco-ploughing vs. Grass-growing

Another successful example of collaborative cultural heritage management is the Groningen terp project (the Netherlands). Intense agricultural activity since the Second World War has jeopardized the natural preservation of numerous terps. One of the major threats was (and still is) deep ploughing, which gradually erodes the ground surface, exposing and damaging archaeological remains. Experiments have shown that eco-ploughing (e.g. surface ploughing, rather than deep ploughing) produces, in some cases (e.g. with the seed potato), better crops. This is not only beneficial to the farming production, but it also reduces erosion around the edges of the terps. The Groningen project has also shown that, contrary to previous belief, allowing grass to grow over the terps is not always a good solution, for it could cause considerable water run-off and evaporation, hence destabilizing the hydrology (e.g. water-table) of the area. On the other hand, eco-ploughing may, in fact, facilitate the retention of humidity, vital for the preservation of the archaeological organic material (van Dockum et al., 2001). The success of the Groningen project is yet another example of the importance of strategic management plans that encompass, and agree with, local communities' expectations. A little compromise is usually the key to better long-term management sustainability.

The Groningen project is certainly not the only example of positive cultural heritage protection in the Netherlands. In fact, the National Service for

Archaeological Heritage (previously the ROB, but renamed RACM after merging with the Netherlands Department for Conservation in 2006) has been carrying out a number of projects to study preservation processes of *in situ* archaeological remains in a variety of waterlogged contexts. The focus of the research spans from erosion on coastal areas (see e.g. the Valkenisse Medieval village in the Zeeland province), to the stabilization of water-tables, and chemical processes of preservation of organic remains in anaerobic conditions (e.g. the Late Neolithic site of Spijkenisse-Vriesland in the Zuid-Holland province) (van Heeringen and Theunissen, 2006, 2007) (see also Ch. 5).

COMMUNITY ARCHAEOLOGY

The last part of this chapter is dedicated to an often overlooked aspect of archaeology: the relationship between archaeologists and the local communities where archaeological projects take place. This close interaction and collaboration between researchers from outside and local people is also known as 'community archaeology'. Community archaeology is not simply legal courtesy (e.g. seeking permission from local communities to work in specific areas), but involves working actively with local communities in a way that values their (the communities) options and meets their needs (Marshall, 2009). This kind of synergetic collaboration requires a lot of effort and compromise (from both sides), but if successful, can be exceedingly rewarding. One of the first and very successful archaeological projects based in large part on community archaeology was the excavation of the Ozette village (Northwest Coast of the United States), which was carried out with the support of the Makah local community in the 1960s–1970s (Daugherty and Friedman, 1983). Successful collaboration between archaeologists and local communities on the Northwest Coast of North America did not stop with Ozette, but, thanks to the remarkable work of Dale Croes at Hoko River and Qwu?gwes (Croes, 1995, 1999, 2010; Croes et al., 2005, 2007), it has continued to the present. Similar examples are also found in Australia (Field et al., 2000; Greer et al., 2002; R. Harrison, 2004) and in New Zealand (e.g. the Pouerua project), where such initiatives have succeeded in bringing together Maori and non-Maori local communities, giving them the opportunity to discover and discuss their different, but now unified, cultural heritage (Sutton et al., 2003).

Community archaeology can be a powerful tool to develop cultural heritage management strategies. Encouraging local people (of different social and cultural backgrounds) to become interested in their cultural heritage is the first step to successful negotiations that will lead to appreciation and eventually protection of it. This highlights once again the importance of public involvement in all aspects of cultural heritage management, from academic

research to political decisions. It is by sharing information rather than withholding it that the best results are achieved.

CONCLUSION

Lack of monumentality of organic waterlogged archaeological remains, along with a rather excessive emphasis placed upon scientific explanations, has made it more difficult for laypeople to appreciate the real value of wetland cultural heritage. Although popular archaeology literature (archaeology magazines) has tried to bridge the gap between academic research and the public, scholars have reluctantly adhered to this initiative, arguing that simplifying explanations too much would diminish the scientific value of archaeological rationale. Moreover, the fact that these publications have little value in the academic world has further discouraged scholars (working within academia) to publish papers in them.

One area that has certainly not suffered any setback in relation to wetland archaeological discoveries is the media. In fact, TV documentaries and programmes have been thriving on archaeological remains found in waterlogged contexts. Although harshly criticized by academic archaeologists, these programmes have contributed greatly to the popularization of the wetlands and their rich cultural heritage. A significant effort to inform the public on the immense importance of well-preserved organic archaeological remains has been done by open-air museums, which have been able to link archaeological evidence to the visitors' expectations. Their pedagogical character linked to the 'hands-on' concept of learning encourages people to be fully immersed in a past-like environment (created by the replicated ancient settings—e.g. architectural structures), and become part of the setting. Not only does this facilitate the assimilation of the information, but it also helps people to remember it for longer. By continually interacting with the visitors, open-air museums adapt to people's demands. Pedagogical institutions such as these are therefore more prone to understand the visitors' responses and modify both teaching methodologies and the way archaeological artefacts are presented. However, this constantly evolving process can be implemented only through synergetic interaction and collaboration between experts and visitors.

In addition to making the public interested in wetland archaeological cultural heritage, one of the main concerns of these institutions, and indeed of all scholars involved in wetland heritage management, should be that of raising awareness about the urgent need for protection of wetland ecosystems. Despite the various efforts made in the past three decades to emphasize the importance of preserving these delicate environments, wetlands are still disappearing at a fast pace, taking with them all their invaluable cultural heritage.

It would be wrong to say that little has been done about it. In fact, as discussed above, some organizations at either national or international level have achieved great results. However, there is a need for more integrated management by the relevant administrations and agencies as well as wetland heritage managers and archaeologists. Defining specific heritage values is not enough; it is necessary to identify the convergences between these and other biological values that are crucial for the conservation and sustainable use of the wetlands. This can be achieved only if all these values are incorporated in active legislative instruments, properly articulated, with national as well as local legislation. It is furthermore crucial that all the parties involved in wetland (cultural and natural) heritage management accept all the different values and use them to resolve conflicting management priorities. Archaeologists and wetland heritage managers should be realistic and recognize the broader benefit for the general public. It is vital to be flexible when making strategic management decisions, and to be prepared to make sacrifices and to compromise in favour of the well-being of the entire community, rather than prioritize single, individualistic aspects. A key point for successful preservation strategies is to find joint objectives within the many divergent ones, and be prepared to tailor them to the main priorities. Protecting our cultural and natural environments is not about preventing change, but enabling management of that change. Finally, whoever is dealing with wetland heritage management has to be ready to be involved at all levels, from the scientific to the political. Declining responsibility by using ignorance as an excuse is no longer acceptable.

Epilogue

The intention of this epilogue is not simply that of summarizing the content of each chapter, but that of highlighting the most prominent aspects of wetland archaeological research considered throughout the volume, leading the discussion towards possible future orientations within the discipline. It has been argued, that despite its great potential and the enormous contributions it makes to a number of different disciplines, wetland archaeology not only has difficulties in integrating into its parent discipline of archaeology, but in some countries has even become an isolated entity, compromising the effectiveness of the archaeological reasoning as a whole (Van de Noort and O'Sullivan, 2006). This localized isolation is, however, not only due to an inapt attitude towards research (a too environmental-deterministic and functionalist orientation, a lack of consideration of the social aspect and people's identity, and inadequate, if not absent, theoretical elaborations), but is also rooted in long-term endemic research traditions, which are the result of a series of interwoven factors traceable to the initial development of post-processual archaeology in Britain and the United States in the 1980s (Hodder, 1982; Hodder and Preucel, 1996; Trigger, 1989) (see Ch. 1). It is important to point out, though, that even where this isolation has not occurred (e.g. mainland Europe), a full integration of wetland archaeological research into mainstream archaeology has not taken place either. In fact, despite wetland archaeology (and related wetland archaeological projects) being considered part of the parent discipline of archaeology, the full potential of the sub-discipline has not as yet been realized and/or exploited. However, as it is discussed throughout the book, the attitude of wetland archaeologists towards wetland archaeological research has been changing significantly in the past two decades or so; shortcomings and prejudices towards the discipline have been faced, solutions found, and the first results have already started to appear (see Ch. 8).

The long, but by no means exhaustive, list of wet/wetland sites discussed in Chapter 2 highlights the importance of contextualizing the sites within a wider geographical and cultural sphere. In very dynamic ecosystems people were, and are, often forced to be highly mobile in terms of choosing and using their

settling areas, and had to adapt continuously to the changing environment. This constant transformation of the surrounding environment influences both cultural and physical aspects of human behaviour. Chapter 3, for instance, shows that the people–environment interaction is certainly not a one-way relationship, but the result of a series of complex cause/effect chain-reaction factors that affect both entities. We have seen how environmental change (caused by both natural and human-induced influence) may have negative repercussions on people's subsistence, which, in turn, influences their physiological needs, eventually resulting in an abuse of their surrounding habitat (see also Box 3.1). This vicious circle continues until one of the two parties is able to step out. Amongst the myriad of possible solutions, migration seems to be one of the most adopted. Whether caused by natural or cultural phenomena, or encompassing vast or limited movements, migrations always involve a series of aspects, which can result in either success or failure of the group or community's relocation adjustment and adaptation to the 'new' settling area. It is the people's capability of acquiring limitational, locational, and social landscape knowledge that will determine the ability to overcome possible population, social, and knowledge barriers (Gamble, 1993; Rockman, 2003) (see Ch. 3, under 'Expanding and Adapting to New Environments'). The ultimate goal of Chapter 3 is that of emphasizing the ambiguous role of culture in human adaptability. We all know that cultural knowledge provides information useful for survival. The ability to learn from past experience (from our elders and/or ancestors) and combine that knowledge with our own experience is the key to a successful survival strategy. However, past experience may (in some cases) no longer be accurate enough to cope with present situations. Therefore, people's survival success rate depends upon the ability to adopt the right strategy for the right moment. If the pace of change increases, the fissure between environmental and cultural change tends to broaden, increasing the possibility of making inadequate decisions, which inexorably lead to a crisis and/or failure of survival strategies (Moran, 2000). On the other hand, steady transformations are coped with better, and in various cases the change itself (even if it may seem negative—e.g. sea-level rise) may have advantages (see e.g. the dynamic landscape change on the Baltic Sea coasts during the Mesolithic—Ch. 2, under 'Mesolithic').

Causes and effects of people's choices become trapped into people's material culture and the surrounding environment itself. Because of the exceptional level of preservation of organic archaeological material in waterlogged environments, evidence of those 'choices' is identified more easily. However, as discussed in Chapter 4, the richness of some archaeological sites and the scarcity of others is not always the result of good and bad preservation, but a combination of geographical and cultural factors. See, for instance, the sharp decline of Iron Age prehistoric lacustrine villages in the Circum-Alpine region, as opposed to contemporaneous crannogs in Scotland, which increased in

number. Or, the intra- and interregional variety of house types, which certainly deserve explanations that go beyond a simple environmental-deterministic reason. The same can also be said for short- and long-distance trade routes, which are better understood when the various means of transport and communication networks (rivers, canals, paths, and wooden trackways) are taken into account within different spatial/temporal scales.

As discussed throughout the volume, well-preserved artefacts do not speak for themselves; only via a solid network of theoretical approaches have they the capability of joining the various pieces of the jigsaw puzzle. For example, basketry can detect cultural change (see the Northwest Coast of North America), while weirs and fish-traps are able to identify different economies, as well as ancient fishery management, in relation to seasonal availability. Bog bodies, underwater cemeteries, hoards, and sacrificial offerings, on the other hand, tell us more about people's perception and interaction with those seemingly inhospitable, yet richly enculturated environments.

Unfortunately, 'all that glitters is not gold'! The various advantages of wetland archaeology are, alas, matched by a similar number of shortcomings, the majority of which are at the practical level. It is well known that an exceedingly large number of wet/wetland discoveries are made serendipitously. This is not merely due to the inaccessibility of wetland areas, but more to the difficulty of detecting archaeological remains in waterlogged conditions. In fact, the similar consistency of organic artefacts to the surrounding matrix (soil, peat, etc.), prevents conventional surveying methods from distinguishing the former from the latter. Although as argued in Chapter 5, a few new surveying techniques (in both waterlogged terrains and under water) have been developed recently, the problem still remains. Difficulties continue if excavation of a wet/wetland/underwater site has to be carried out. As discussed in the 'Excavation' section of Chapter 5, a number of excavation methods, able to adapt to a variety of wet environments, are readily available to archaeologists. However, wherever possible protection measures have been prioritized (from stabilizing the water-table (e.g. redox potential) in waterlogged terrains, to anti-erosion measures (e.g. geo-textile blankets) on lake shores, river banks, and coastal areas) (Corfield, 2007; Ramseyer and Roulière-Lambert, 2006). Emphasis has also been placed upon conservation techniques. Not only are the various methods discussed in terms of efficiency and costs, but also with regard to durability. An apparently well-conserved artefact may encounter unexpected side-effects in the long run.

Despite these practical difficulties (time-consuming and costly survey, excavation, preservation, and conservation methods), the potential of wetland archaeology within the parent discipline (mainstream archaeology) and beyond is enormous. The multi-disciplinary character of wetland archaeological research discussed in Chapter 6 shows the advantages of synergetic collaboration. Although each discipline may still have specific tasks, the strength of

joining forces is that of making it possible to back up or reject weak results of one single discipline. For instance, palaeoenvironmental reconstructions obtained from collaborative work between archaeobotany, geoarchaeology, and palaeoclimatology should be confirmed by dendrochronology (not only in terms of dating, but also in relation to the discipline's various sub-branches, e.g. dendrotypology, wood technology, and dendrology), as much as dendrochronology itself may need archaeoentomology to find out whether a tree was used (as building material) straight after it was felled or much later (Lemdahl, 2004). The same can be said for other issues such as animal and plant migration/domestication. Archaeobotanical and archaeozoological studies may require the help of ancient DNA analysis to identify genetic changes as a result of human manipulation, which is not recognizable through the morphological characteristics of single specimens (Schlumbaum et al., 2008). Even the most widespread dating technique, radiocarbon (^{14}C), needs help from other dating methods to rectify its accuracy. In fact, both dendrochronology and the varve dating method are used to calibrate ^{14}C dates; the former up to about 12,000 years ago, whereas the latter is used for dates beyond that limit (Kitagawa and van der Plicht, 1998; Reimer et al., 2004, 2009). At the same time, dendrochronology does sometimes need help from ^{14}C dating technique. For instance, where complete (master) tree-ring sequences are not available, high-precision radiocarbon dates are obtained from within a sequence of relatively dated material (e.g. a floating tree-ring sequence), and the results are then fitted into the calibration curve (wiggle-match), using statistical methods (Bronk Ramsey et al., 2001; Galimberti et al., 2004).

Not only do well-preserved artefacts found in waterlogged contexts give archaeologists the possibility of identifying the function of those objects, but also that of replicating them and testing their performance. As discussed in Chapter 7, experimental work on archaeologic artefacts covers three (perhaps four) different (but interwoven) levels (Coles, 1979). Level one consists of the reproduction of objects for pure aesthetic reasons (e.g. for museum displays), whereas levels two and three test the technology (linked to the process of production and manufacture), and the presumptive (even speculative) purpose of the artefacts, respectively. A fourth level (which is becoming more and more part of the experimental process lately) crosses the boundaries of physical archaeological evidence, entering that of human agency, and stressing the importance of 'who made the objects', rather than the objects themselves (Harris, 2008). Good preservation plays an important role in the identification of an object's function; the better preserved an artefact is, the higher is the chance for us to identify its function. However, a number of functional objects have undergone technological development and changed their appearance completely, preventing archaeologists from recognizing them. Ethnographic research and a close collaboration with ethnic groups, with technological advances still deeply rooted in the past, may be in this case of

great help in avoiding unsubstantiated guesses. An area of experimental archaeology particularly linked to wet/wetland finds is the reconstruction of full-size prehistoric habitations. The aim of their reproduction is not purely aesthetic, but often encompasses all four levels of experimental work mentioned above (including testing of construction tools, and depositional as well as site formation processes) (Krauss et al., 1999; Monnier et al., 1991). Other experimental work in archaeology, which has been taking advantage of the large amount of well-preserved archaeological data found in waterlogged contexts in the past two decades or so, is experimental crop cultivation. The particularly fruitful work carried out in tandem with archaeobotany has yielded important results concerning seasonal cultivation and subsistence strategies (Rösch et al., 2008) (see also Ch. 7, under 'Experimental Crop Cultivation', and Table 6.1).

FUTURE ORIENTATIONS

Despite outstanding efforts to (re)integrate wetland archaeology into mainstream archaeological reasoning (see Ch. 8), entirely satisfying results have yet to be achieved. Possible shortcomings, which have caused the discipline's isolation in some countries, and/or hindered its long-overdue full integration in others, have been highlighted throughout this volume. Along with the work of other scholars, the book has argued for a proper contextualization of wet/wetland sites into a wider geographical as well as sociocultural area, more emphasis placed on people's identity, and, finally, the development of an apt, solid body of theory, for artefacts alone, even the best-preserved ones, do not speak for themselves.

Because of the large amount of well-preserved ecofacts found in waterlogged contexts, there is always the danger of channelling wetland archaeology towards environmental-deterministic research orientations. However, as pointed out above, people–environment interaction is the result of a series of complex cause/effect factors that affect both units. As clearly shown by recent studies (Doppler et al., 2010), rich ecofact assemblages combined with artefact-oriented spatial analysis, modelling, and solid theoretical elaborations, can certainly be used to shed light on the social aspects of the community without necessarily embarking on environmentally determined socio-economic and subsistence analyses.

Another advantage offered by the high-resolution archaeological data found in waterlogged environments is the possibility of reconstructing biographies of objects, habitations, and other architectural structures. The life-history approach to material cultural is germane to understand the different phases that artefacts (including houses) go through during their existence, and the

different meanings that they acquire or lose (Gell, 1998; Ingold, 1995). It is, for instance, by linking the crucial moments of a house's life-cycle, such as planning, construction processes, occupation, and abandonment, that social structure, reflected and determined by the single house itself, can be better identified (Kopytoff, 1986; Shanks and Tilley, 1987; Tringham, 1995).

Wetland archaeology has certainly the possibility, capability, tools, and willingness to move forward and become fully integrated into mainstream archaeology. However, the future of the discipline is currently facing a significant threat that goes far beyond the practical and theoretical aspects of academic research: the relentless disappearance of wetland ecosystems and, with them, our invaluable cultural heritage. Wetland archaeology has the responsibility of making the general public aware of the danger that all of us are facing. Being fully integrated (as an academic research discipline) also means communicating more with the public, letting people know what wetland archaeology is about, divulging scientific results, methodology, advantages, and disadvantages. Museums and open-air museums have achieved outstanding results in the past two decades (see Ch. 9). People are now more aware of the incumbent danger that is threatening our cultural heritage in the wetlands, but unfortunately, despite the various successful initiatives promoted by wetland archaeologists and completed in collaboration with local authorities and governmental bodies (see Ch. 9, under 'Protective Scheme Implementations: Successful Initiatives'), the wetlands are still 'evaporating' at a frightening pace. Notwithstanding its good intentions, this is a battle that wetland archaeology alone cannot win. There is a need for more integrated management and more involvement of administrative agencies, wetland heritage managers, and archaeologists. More than confronting specific heritage values, we need to identify the intersecting points between these values and other priority values (within the society) that are crucial for the conservation and sustainable use of the wetlands. These actions, however, can be effective only if incorporated in active legislative instruments, with a proper articulation within local, national, and international legislations. We all need to acknowledge that preserving the past is not necessarily about preventing change, but rather how to manage it. Wetland archaeology is, unfortunately, facing the paradox of a successfully expanding discipline overlying a relentlessly shrinking research milieu. Negative perceptions argue for a continuation of this trend, whereas more positive ones hope for people's common sense to win through.

Glossary

Absorption spectrophotometry: analytical technique used to determine the purity or components of a sample solution based on its optical density and light absorption properties

Abstraction: removal of water from a water body (e.g. for irrigation or drinking supply)

Acclimatory adjustment: modest, reversible physiological adjustment to an environmental change or stress

Acrotelm: surface layer of peat having a fluctuating water-table, where aerobic decomposition occurs

Aeolian: wind derived

Aerosols: particles, other than water or ice suspended in the atmosphere

Afforestation: Establishment of a new forest by natural regeneration or plantation on non-forested land

Aggradation: the building up of the land surface by process of sediment accumulation

Allogenic: derived externally from a particular system

Alluvium: material that has been carried in suspension by river or floods, and subsequently deposited

Amensalistic relation: one group inhibit the survival of the other group

Amoebae: a single-celled organism

Anastomizing: braiding of channels

Anoxic: lacking oxygen

Anthracology: the science of charcoal analysis, to determine wood species

Aquifer: permeable or porous rock that allows substantial passage of water

Aquitard: less permeable rock that retains or retards the passage of water

Autogenic: relating to a process generated inside a particular system

Autolysis: the digestion of a cell by itself

Backswamp: a boggy depression in floodplain beyond the levée

Bajos: types of field cultivation, particularly common in Mesoamerica

Biodiversity: the variety of all life on earth

Biogenic: deriving from organic remains

Biomass: total mass of living organism present at a given moment in a population or area

Biome: a broad ecological unit, characterized by a set of climatic parameters and types of floral and faunal associations

Biostratigraphy: subdivision of sediment sequence based on changes in contained biological assemblages

Biota: the flora and fauna of a region or ecosystem

Bog iron: iron deposits that form in bogs as a result of oxidization and deposition of iron minerals that were formerly carried in water solution. The formation of a bog iron layer will increase the development of the bog, as the iron layer becomes impermeable and promotes waterlogged conditions above it

Brown adipose tissue: the primary tissue responsible for chemical heat production or non-shivering thermogenesis

Carr: usually alder carr—also a temperate swamp

Catotelm: anaerobic layer of peat, found below the acrotelm, which does not have a fluctuating water level and no peat-forming organisms are present

Cenote: a sinkhole with exposed rocky edges containing a volume of groundwater. Typically found in the Yucatán peninsula

Chironomids: a variety of small non-biting insects or midges with global distribution

Chloroplast markers: genetics units in the chloroplast genome of plants

Chronostratigraphy: subdivision of a sediment sequence (usually radiocarbon-dated) based upon age

Chronozone: a chronostratigraphic unit that is based upon a stratigraphic unit, which has been absolutely dated

Circadian rhythm: daily rhythms that characterize the species (the rhythm is set by environmental synchronizers, e.g. light, temperature, etc.)

Circannual rhythm: yearly biological rhythm that reflects seasonal changes in the environment

Cladocera: small crustaceans, commonly known as 'water fleas'

Clastic: containing fragments of rock and other debris (gravel, clay, sand, etc.) originating from elsewhere

Colluvial: sediment that has accumulated below a slope due to erosion processes

Commensalistic relation: a relation where one group remains unaffected by its interaction with another group

Constrains: intervening variables present in the environment that may alter the effects of a process, flow, or state

Contact zones: a direct interface between two habitat types (e.g. the edge of a lake)

Coprolite: fossilized animal dung

Coversand: accumulation of sand deposits by wind action

Cultural adjustment: the learned knowledge that people acquire as members of society, and that permits them to respond rapidly to changes within the environment

Darcy's Law (Henri Darcy): describes the slow flow of liquids through homogeneous porous media. Fast flow (e.g. in karst areas) does not adhere to the law

Deepwell: a shallow (up to around 4 metres) lined hole in a wetland substrate which allows the measurement of shallow groundwater levels. (A different type of deepwell is also used for dewatering systems during wetland excavations)

Dendrochronology: the dating of past events and variations in the environment and climate by studying the annual growth rates of trees

Developmental adjustment: non-reversible physiological and morphological changes resulting from organismic adaptation to environmental conditions during the individual's development

Diapause: temporal interruption of growth associated with a period of dormancy

Diatoms: microscopic plants of single-celled or colonial algae found in both salt and fresh water

Dormant: a period of reduced biological activity (e.g. hibernation)

Eat-outs: cleared areas of marshland that develop pools

Ecosystem: assemblage of living and non-living components in an environment together with their interrelations

Ecotone: an area on the boundary between different types of environment

Ecotype: group of organisms of the same species, which have developed special adaptations (physiological and/or morphological) to a certain combination of environmental factors

Edaphic: environmental conditions that are determined by soil characteristics

El Niño: an oceanic event lasting several months and associated with an extensive warming of sea surface temperature across the central and eastern equatorial Pacific Ocean

Eluviation: washing out of dissolved components of a soil (e.g. by rain)

Endemic: restricted in distribution to a certain area or region

Endoreic: a 'closed basin'. A lake which has no outflow, either above or below ground surface level (water leaves by evaporation only)

Energy flow: the changes in energy form in a system as it moves from one component to another

Entrenchment: erosion by a freely flowing stream to form a canyon

Entropy: increased disorder in a system due to loss of potential energy

Ethnogenesis hypotheses: a theory that interprets cultural change and cultural similarities as the result of individuals within societies copying each other, thus reproducing their practices, beliefs, and systems

Eustatic rise: a global rise in oceanic water level caused for example by the melting of land-based glaciers

Eutrophic: rich in nutrients; highly productive in terms of organic matter

Evapotranspiration: combined loss of water from the earth's surface by evaporation from open water and soil surfaces and transpiration from the leaves of plants

Exoreic: drainage basin with an outlet to coastal water

Fen: minerotrophic mire, characterized by accumulation of non-acid peat and which supports fen communities (e.g. alder and reeds)

Floodplain mire: minerotrophic mire characterized by fen communities

Foramifera: microscopic benthic organisms living in saline conditions

Genotype: the genetic contribution of an organism or its hereditary potential

Gerontocratic: a form of political structure in which power and leadership accrues in members who are significantly older than the remaining adult population

Glutenin: a protein derived from wheat, used in organisms in the creation of gluten

Grog: crushed fired pottery of any type which is added to clay as temper

Groundwater: water flowing or stored underground, especially that in the zone of saturation

Group fissioning: the splitting up of villages or kin groups and their re-establishment in smaller, independent units (used as strategy to lower population pressure)

Gyttja: a nutrient-rich plant- and plankton-derived peat

Halophyte: salt-tolerant plants

High performance liquid chromatography (HPLC): also called 'High Pressure Liquid Chromatography', this is a method of column chromatography used to identify and quantify the components of a solution

Humic-iron pan formation: the slow deposition of iron minerals as a layer, an 'iron pan' as rainwater percolates through soil. The iron pan eventually becomes impermeable and results in the waterlogging of the soil above
Humification: degree of decomposition of plant remains
Hummock: a hillock; knoll; a ridge or mound of ice in an ice field
Humus: product of decomposition of organic matter found in soils
Hydraulic gradient: the slope of the water table in an aquifer
Hydrolysis: a chemical reaction used to break down polymers, in which a compound reacts with water
Hydromorphic soils: soils formed under conditions of poor drainage in marshes and swamps
Hydroperiod: duration or frequency of flooding or level of the water-table
Hydrophyte: a plant adapted to aquatic or semi-aquatic conditions
Hydroseral: the succession from open water to fen and finally to raised mire
Illuviation: the deposition of material removed from an upper soil horizon
Inlet: a short, narrow waterway connecting a bay or lagoon with the sea
Intercropping: a practice of planting several crop species on one field simultaneously
Interflow: the lateral, subsurface flow of water derived from precipitation
Interfluve: an area of land between two rivers
Interstadial: a short, warmer interval within a full glacial stage of an ice age
Intertidal: the area between the high and low water marks, which is exposed at low tide
Isostatic uplift: slow rise of the terrain, where ice sheets have melted
Kettle-hole: a bowl-shaped depression with steep sides in glacial drift deposits that is formed by the melting of glacier ice left behind by the retreating glacier
Lagoon: a small body of normally shallow water isolated from related, and normally much larger, water bodies
Land reclamation: gaining land in a wet area such as a marsh or sea flat
Landscape ecology: specialization that deals with the patterns and processes of biological systems in spatially and temporally heterogeneous environments
Leaching: the removal of soluble mineral salts from the upper layers of a soil by the movement of water through the horizons
Lentic: a water body with largely still water (e.g. a pond or a lake)
Levée: long-crested ridge alongside a stream channel constructed by deposits of floodwaters when they overtop the channel banks
Lithostratigraphy: subdivision of a geological sequence based upon variations in the nature of the sediments
Litoral: near shore, roughly within a depth to which light and wave action reach
Loess: wind-blown deposit, especially of sediments
Lysimeter: device for measuring the percolation of water through soils and determining the soluble constituents removed in the drainage
Macrophytes: aquatic plants growing in water that are either emergent, submergent, or floating
Marsh: a transitional land-water area, covered at least part of the time by surface water or saturated by groundwater at or near the surface
Mean sea level (MSL): the average height of the sea surface, based upon hourly observation of the tide on the open coast

Mesotrophic: intermediate nutrient status

Micro-beam diffraction: a method for the identification of crystalline minerals by observing the diffraction patterns of a light beam directed at the crystalline mineral

Micro-fluorescence: a non-destructive method for the detection and identification of organic residues of polymer materials

Microsatellites: highly variable units in the genome, consisting of two, three, or more nucleotide repeats of variable number

Minerotrophic: mire with water input (containing nutrients) from groundwater

Mire: general term for a peat-producing ecosystem

Mitigation (also 'mitigation banking'): substitution of a site that is to be degraded. Permission to develop a site can be granted on the condition that another wetland area (the 'mitigation wetland') is created with height functional values that match those lost in the development

Mollisols: soils rich in organic content forming in semi-arid to semi-humid environments, generally associated with North American, South American grasslands, and Asian steppes

Monsoon: a seasonal reversal of wind, which in the summer season blows onshore, bringing with it heavy rains, and in winter blows offshore

Morass: a tract of swampy, low-lying land

Morphotype: organisms that are classified together based on similar physical characteristics

Muck: well-decomposed organic soil (general US term for peaty soil)

Multispectral Scanner (MSS): a sensor that collects data from the same area of the earth at different wavelengths of the electromagnetic spectrum

Mutualistic relation: two groups favouring the well-being of one another, without depending on each other

Niche: all the components of the environment with which the organism or population interacts

Oligotrophic: low-nutrient status

Ombrotrophic: a type of peatland that receives all its water and nutrients from precipitation

Oxbow lake: a lake formed in a former riverbed, when a bend in a meandering river is cut off from the main stream

Oxisols: soil type formed in tropical rain forests, with a characteristic red or yellow colour due to high concentrations of iron and aluminium oxides while having a general lack of organic content

Oxygen Isotope Stages (OIS): the designated climatic stages in the standardized ocean-sediment records

Palaeosol: a 'fossilized' soil or land surface that has been preserved beneath sediments or volcanic deposits

Paludification: the process by which an area is converted into mire through progressive waterlogging and peat formation

Peat: dark brown or black residuum produced by the partial decomposition and disintegration of mosses, sedges, trees, and other plants that grow in wet ecosystems

Pedology: the study of soils

Percolation: essentially the process of water movement through the soil and rock in the unsaturated (or vadose) zone

pH: the scale along which acidity/alkalinity of a solution is measured

Phenology: the study of the timing of the different stages of vegetation from year to year, covering leaf opening, flowering, fruiting, and leaf fall that can be used to establish evidence of climate change

Phenotype: the physical manifestation of the hereditary potential of an organism

Phreatic: lying below the water-table

Phylogenesis hypotheses: an explanation of the similarities and differences between cultures based upon the principle of cultural division over time, which can be charted in a manner similar to biological evolution; as cultures grow and separate so cultural traits become differentiated

Phytolith: silica deposited in the secondary plant wall of some plants (in particular grasses), which is well preserved in sedimentary deposits and can be used to identify the prevalence of specific plant types

Piezometer: a shallow, lined hole in the wetland substrate allowing the measurement of the piezometric surface in a shallow aquifer

Polder: land reclaimed from the sea or other body of water by the construction of an embankment to restrain the water

Pollarding: the periodic reduction of trees back to the main trunk so that a mass of new growth sprouts from the top

Pollen zone: a subdivision of a stratigraphic sequence based upon similarities in the contained pollen, which is distinct in terms of species and abundance from surrounding sediments

Population pressure: refers to the relationship between population size and the ability of the ecosystem to sustain it

Porous rock: rock able to absorb water

Prairie pothole: a shallow pond derived from glacial retreat (usually in the North American Great Plains)

Precipitation: the deposition of water from the atmosphere in solid or liquid form

Primary production: refers to either the assimilation of energy and nutrients by green plants (gross primary production), or to its accumulation and transformation into biomass (net primary production)

Raised mire: a type of mire with a gentle dome profile, supporting typical ombrotrophic mire communities

Ramsar: conference venue on the Caspian Sea, Iran; shorthand for Ramsar Convention on Wetlands of International Importance

Redox potential: Abbreviation for reduction potential—oxidation potential; a measure of the electron pressure (or availability) in a solution (often used to quantify the degree of electrochemical reduction in wetland soils)

Redoximorphic (of soils): mottled iron profiles indicating zones of oxidation and reduction

Regression coefficient: the rate of change of a dependent variable with respect to an independent variable

Regulatory adjustment: an organism's physiological and behavioural responses to changes within its environment

Riparian: linked to a river system

Rivulet: a small stream; a brook

Run off: the water that moves from the land phase of the hydrological cycle to rivers and in most cases the ocean

Saltpan: dry bed of a salt lake after all water has evaporated

Saporels: organic-rich sedimentary layers found in the ocean sediments, which provide evidence of anoxic conditions in the bottom waters of the ocean at the time of depositions

Seawall: an earth, concrete, stone, or metal wall or embankment constructed along a shore to reduce wave erosion and encroachment by the sea

Seepage: the slow movement of water through small openings and spaces in the surface of unsaturated soil

Seiche: standing wave oscillation across the span of a lake (often wind-driven, but can be of seismic origin)

Seral stage: a phase in the sequential development of a climax community of plant succession.

Sere: a process stage in the succession of an ecosystem (e.g. infilling of a lake)

Shoal: a normally submerged bank rising from the bed of a shallow body of water and consisting of, or covered by, unconsolidated material which may be exposed at low water

Soil horizon: a layer of soil with distinctive characteristics

Soil profile: a cross section that includes all the layers or horizons on the soil

Soligenious (fen): fed by upwelling groundwater

Solute: material dissolved in water

Spodic (soil horizon): an iron-rich horizon of a podzol

Stadial: a short, cold period with smaller ice volumes than the full glacial stages of an ice age

Subtidal: the part of the shallow offshore zone that is below the level of the lowest tide

Swamp: a vegetated area perennially flooded or saturated with groundwater

Swidden Agriculture (slash-and-burn): a system in which fields are cropped for fewer years than they are allowed to remain fallow

Synanthropic: found in association with humans

Tannic acid: a commercial form of tannin

Taphonomy: the study of decay and fossilization process of organisms (including archaeological sites) over time

Taxonomy: system of classification that is predicated on the notion of distinctive features, used to separate distinct items into categories of similar items

Telmatic: peat that forms in the swamp zone between high and low water levels

Tephrochronology: a relational chronology created by defining distinct layers of volcanic ash (tephra) in sediment records

Terpen (also known as *Wierden* or *Wurten*) artificially constructed mounds (with a settlement or group of farm steads on top) usually within periodically flooded areas. Typical of Northern Europe

Terrestrialization: process whereby sedimentation and accretion gradually fill the water storage capacity of a wetland

Thermogenesis: refers to the types of mechanisms that initiate heat production in the body

Thixotrophic: relates to sediments that liquefy when saturated

Tidal marsh: brackish wetland systems subject to tidal flow patterns

Toghers: Irish wooden trackways in the wetlands

Topogeneous (fen): associated with locally high groundwater levels

Torrent: steep stream with a strong seasonal regime and short periods with high discharges accompanied by high sediment loads

Trichoptera: an order of insects—the caddis flies—that consists of over 10,000 separate species. Moth-like in appearance, they have two pairs of wings, and produce aquatic larvae

Turbidity: the degree to which turbulent flow maintains suspended sediment in the water giving the water an opaque appearance

UNESCO: United Nations Educational, Scientific, and Cultural Organization

Upland: terrestrial, non-wetland, low-lying areas or hills (not necessarily hilly areas)

Upwelling: vertical movement of water currents near coasts that brings nutrients from the ocean bottom to the surface

Vadose zone: the zone of rock above the water-table

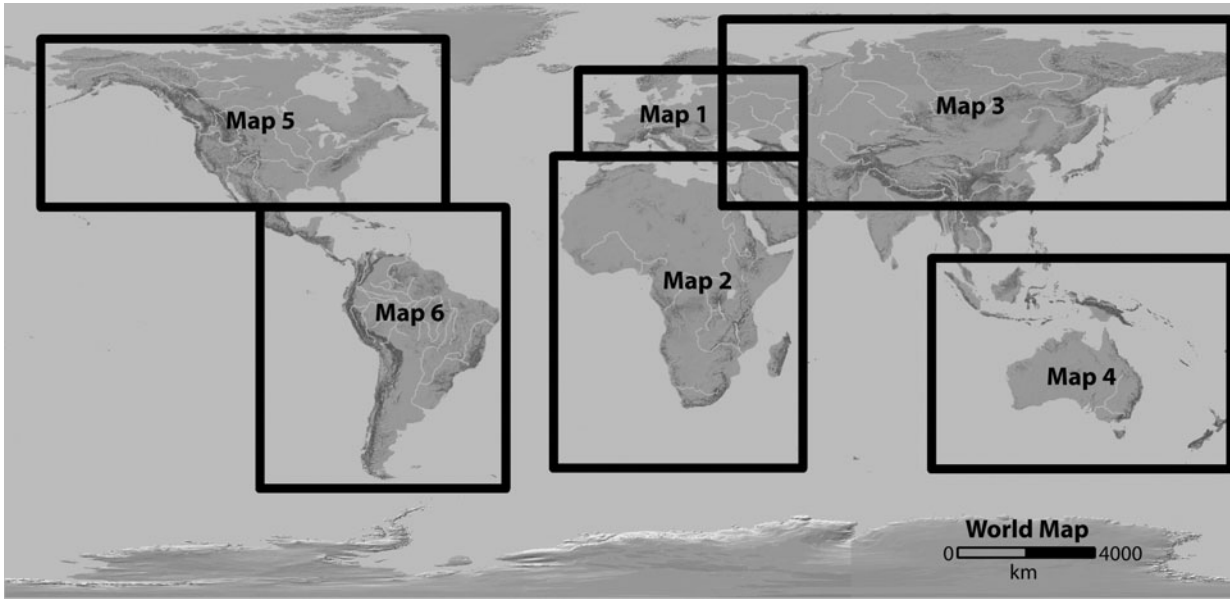
Varve: distinctly and finely stratified clay of glacial origin, deposited in lakes during the retreat stage of glaciation (if these stratifications are seasonal, they can be used to study climatic change)

Vernal: concerning spring (e.g. a pool that dries out in summer)

Wadi: a dried-up desert watercourse, which might become a flash flood after intense rain

Warp: fine clastic alluvium deposited by controlled flooding of an area with sediment tidal water

Water-table: groundwater level below which the soil is saturated with water


Map 5
Map 1
Map 3
Map 2
Map 6
Map 4
World Map
0
4000
km

Maps

MAP SITE NUMBERING

World Map

Map 1: Europe
Map 1A (Belgium, Ireland, the Netherlands, United Kingdom)
Map 1B (Denmark, Germany, Poland, Sweden, the Netherlands)
Map 1C (Belarus, Estonia, Finland, Latvia, Lithuania, Poland, Russia)
Map 1D (North-western Russia)
Map 1Da (North-western Russia—Volga region)
Map 1E (France, Spain)
Map 1F (France, Germany, Italy, Switzerland)
Map 1G (Austria, Hungary, Italy, Slovenia)
Map 1H (Albania, Greece, Italy, Macedonia)

Map 2: Africa
Map 2A (Benin, Botswana, Cameroon, Chad, Congo DRC, Egypt, Lesotho, Mali, Mozambique, Niger, Nigeria, South Africa, Sudan, Tunisia, Zambia)
Map 2B (Ethiopia, Kenya, Tanzania, Uganda)

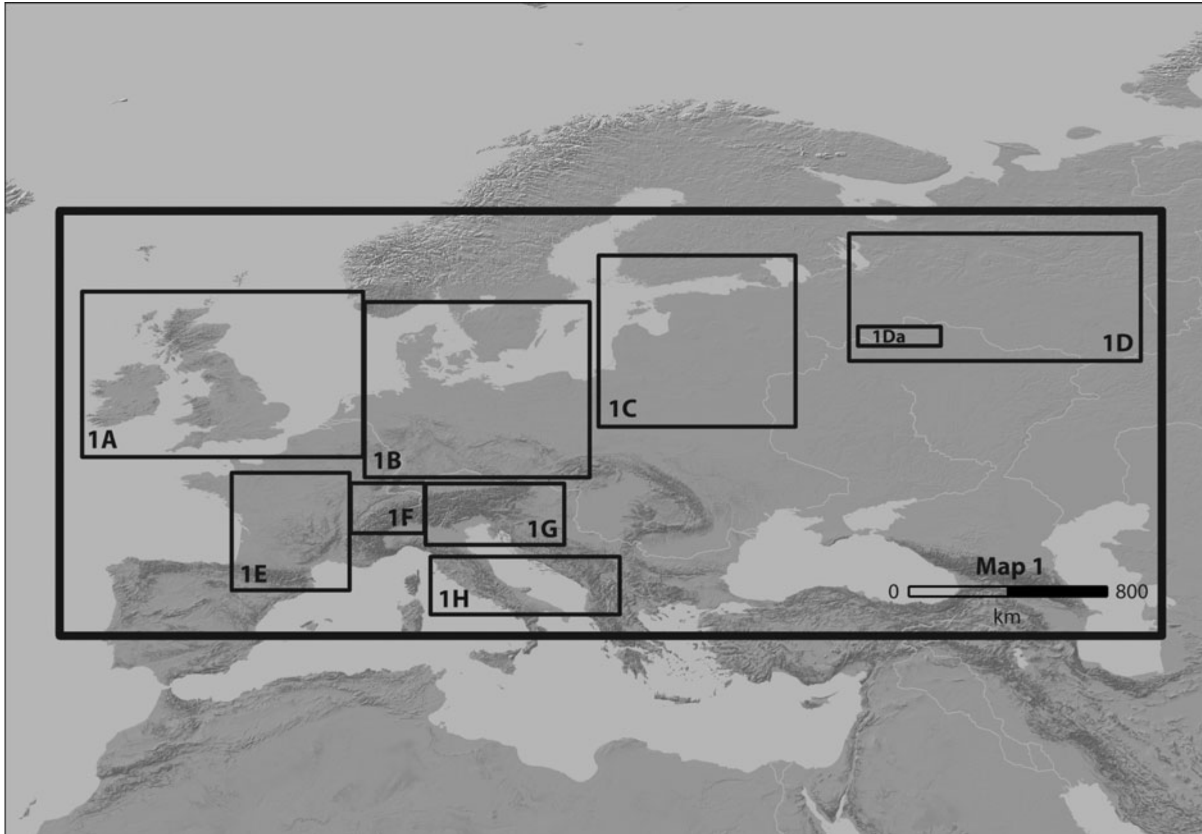
Map 3: Asia
Map 3A (Middle East: Iraq, Israel, Syria, Turkey)
Map 3B (Russia: Middle Urals)
Map 3C (Russian Far East)
Map 3D (China)
Map 3E (Japan)

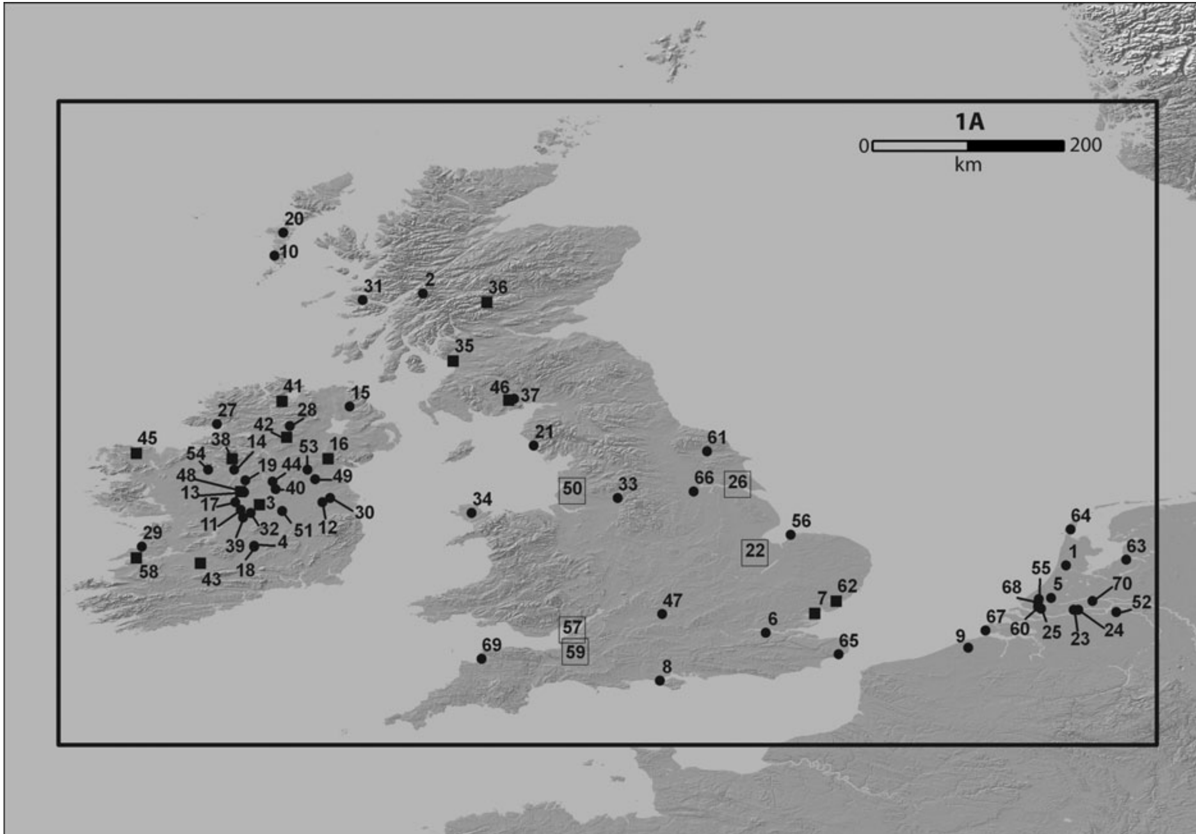
Map 4: Oceania
Map 4A (New Guinea: Irian Jaya [Indonesia], Papua New Guinea)
Map 4B (Australia)
Map 4C (New Zealand—*Aotearoa*)

Map 5: North America
Map 5A (Northwest Coast—Canada, Northwest Coast—United States)
Map 5B (Northwestern United States)
Map 5C (Northeastern Canada, Northeastern United States)
Map 5D (Southeastern United States)

Map 6: Central and South America
Map 6A (Mesoamerica: Belize, Cuba, Guatemala, Mexico)
Map 6B (South America: Bolivia, Brazil, Colombia, Ecuador, Guyana, Peru)
Map 6C (South America: Chile, Uruguay)

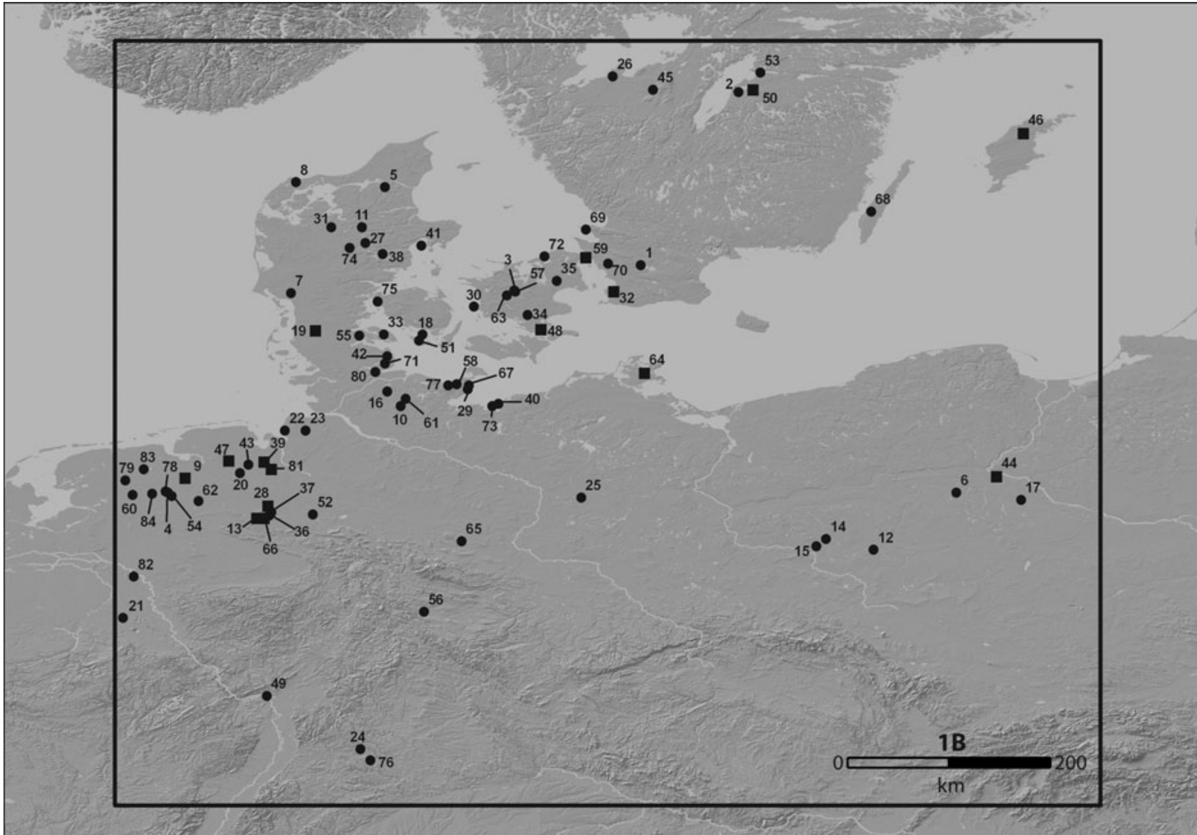
Key: ● = Site; ■ = Area (e.g. lake, marsh, river, etc.)


1A
1B
1C
1D
1Da
1E
1F
1G
1H
Map 1
0
800
km


1A
0
200
km
20
10
31
2
36
35
46
37
41
15
27
28
42
45
38
14
16
53
54
19
44
49
48
40
13
17
3
30
11
32
51
12
39
4
29
18
58
43
21
61
50
33
66
26
34
56
22
64
63
1
55
68
5
70
62
7
52
47
6
67
60
25
24
57
9
23
69
65
59
8

Map 1A
(Belgium, Ireland, the Netherlands, United Kingdom)

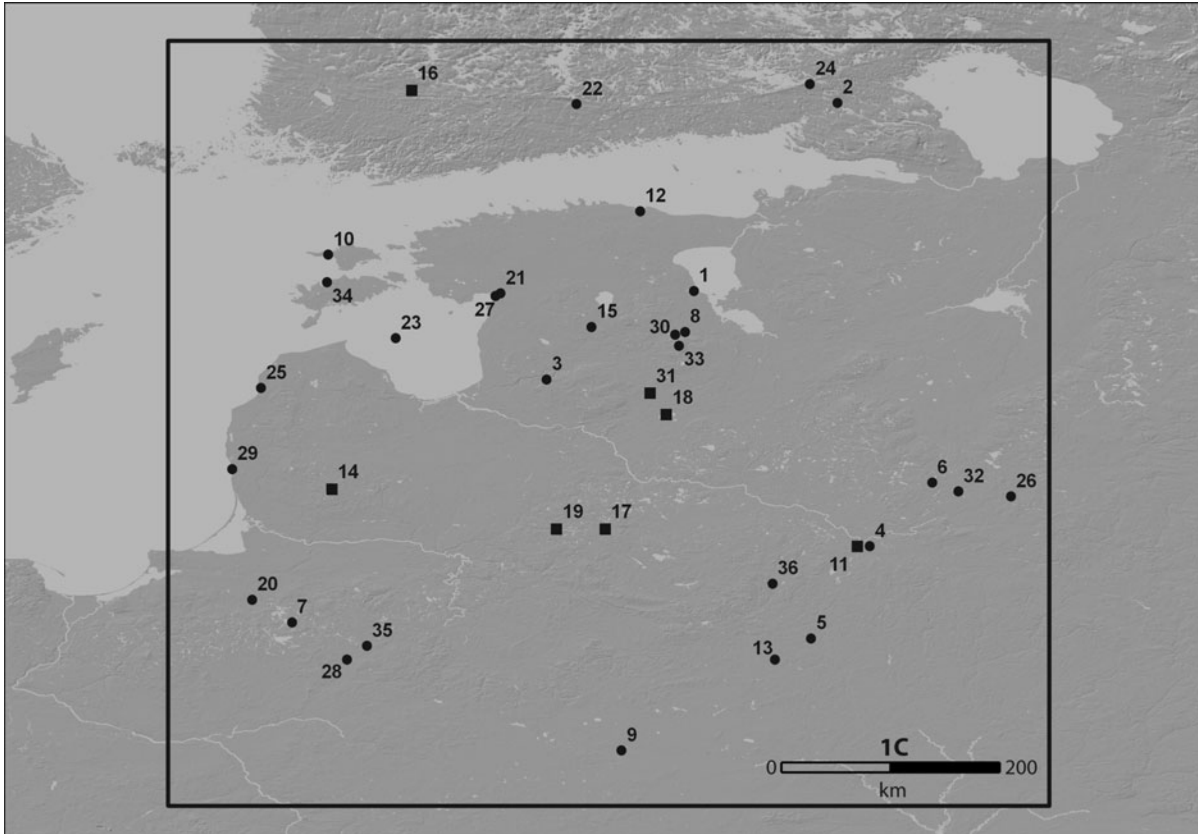
1) Assendelver Polders (the Netherlands): Site Q
2) Ballachulish (Scotland, UK)
3) Ballinderry 1 & 2 (Ireland)
4) Baunaghra (Ireland)
5) Bergschenhoek (the Netherlands)
6) Blackfriars (England, UK)
7) Blackwater Estuary (England, UK)
8) Bouldnor Cliff (England, UK)
9) Bruges Romano-Celtic boat (Belgium)
10) Cladh Hallan (Scotland, UK)
11) Clonfinlough (Ireland)
12) Clonycavan Man (Ireland)
13) Corlea (Ireland)
14) Corlona (Ireland)
15) Craigywarren (Ireland)
16) Cullyhanna Lough (Northern Ireland, UK)
17) Curraghmore (Ireland)
18) Derryville (Ireland)
19) Edercloon (Ireland)
20) Eilian Domhnuill (Scotland, UK)
21) Eskmeals (England, UK)
22) Fenland (England, UK): Cat's Water; Etton; Flag Fen; Flaggrass; Middleton; Newark Road; St James; Stonea Grange; Upwell
23) Hardinxveld (the Netherlands)
24) Hazendonk (the Netherlands)
25) Hekelingen (the Netherlands)
26) Humber Wetlands (England, UK): Adlingfleet; Brigg dugout; Brigg raft; Cawood; Crowle; Drax; Ferriby boats; Hasholme; Kilnsea; Roall; Rossington; Sutton Common
27) Inver (Ireland)
28) Killymoon (Northern Ireland, UK)
29) Knocknalappa (Ireland)
30) Lagore (Ireland)
31) Ledmore (Ireland)
32) Lemanaghan (Ireland)
33) Lindow Man (England, UK)
34) Llyn Cerrig Bach (England, UK)
35) Loch Buiston (Scotland, UK)
36) Loch Tay (Scotland, UK): Oakbank crannog
37) Lochrutton (Scotland, UK)
38) Lough Allen (Ireland)
39) Lough Boora (Ireland)
40) Lough Derravaragh (Ireland)
41) Lough Enagh (Northern Ireland, UK)
42) Lough Eskragh (Northern Ireland, UK)
43) Lough Gur (Ireland)
44) Lough Kinale (Ireland)
45) Lough More (Ireland)
46) Milton Loch (Scotland, UK)
47) Mingies Ditch (England, UK)
48) Mountdillon (Ireland): Corlea; Cloonbony; Derryoghil
49) Moynagh Lough (Ireland)
50) North West Wetlands (England, UK)
51) Old Croghan Man (Ireland)
52) Oss (the Netherlands)
53) Ralaghan (Ireland)
54) Rathtinaun (Ireland)
55) Schipluiden (the Netherlands)
56) Seahenge (England, UK)
57) Severn Estuary (England/Wales, UK): Berland's Farm (Romano-Celtic boat); Brean Down; Caldicot Level; Caldicot boat fragments; Chapel Tump; Cold Harbour Pill; Goldcliff; Goldcliff boat fragments; Magor; Redwick; Rumney; Uskmouth; Wentlooge; Westward Ho!
58) Shannon Estuary (Ireland): Bunratty; Carrigdirty Rock
59) Somerset Levels (England, UK): Abbot's Way; Baker; Bell; Bisgrove; Blakeway; Chilton; Eclipse; Garvin; Jones; Glastonbury; Honeygore; Meare (west and east); Meare Heath; Sweet Track; Tinney; Walton/Rowland; Westhay
60) Spijkenisse-Vriesland (the Netherlands)
61) Star Carr (England, UK)
62) Stour Estuary (England, UK)
63) Switerbant (the Netherlands)
64) Texel-Den Burg (the Netherlands)
65) The Dover boat (England, UK)
66) Thorne Moors (England, UK)
67) Valkenisse (the Netherlands)
68) Vlaardingen (the Netherlands)
69) Westward Ho! (England, UK)
70) Zijderveld (the Netherlands)



1B
0
200
km

Map 1B
(Denmark, Germany, Poland, Sweden, the Netherlands)

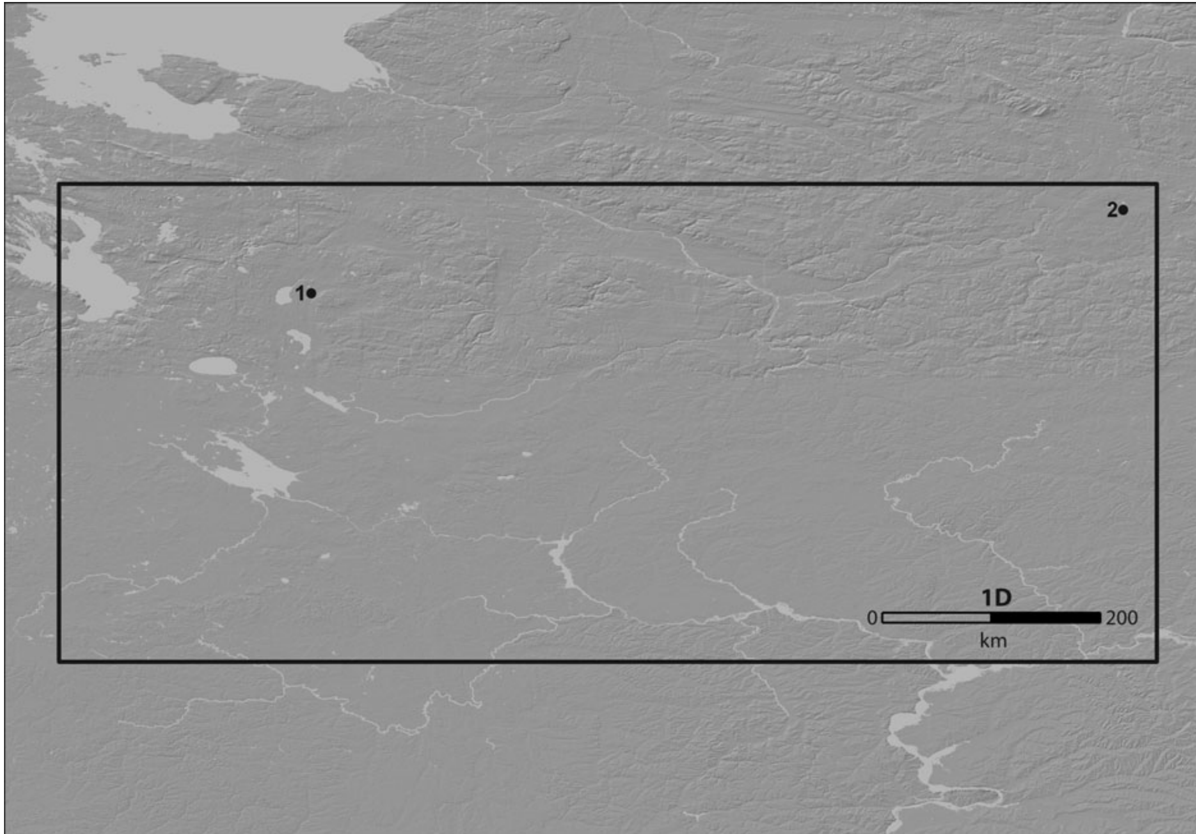
1) Ageröds Mosse (Sweden)
2) Alvastra (Sweden)
3) Åmose (Denmark)
4) Angelslo (the Netherlands)
5) Bejsebakken (Denmark)
6) Biskupin (Poland)
7) Bjerg (Denmark)
8) Bjerre (Denmark)
9) Bourtanger Moor (the Netherlands/ Germany): Bargeroosterveld 'Sanctuary'; Trackway XIV(Bou); Trackway XV (Bou); Trackway XVI(Bou); Trackway XVIII(Bou)
10) Braak (Germany)
11) Broddenbjerg (Denmark)
12) Bruszczewo (Poland)
13) Campemoor (Germany): Trackway XXXI(Pr)
14) Chobienice (Poland)
15) Chwalim (Poland)
16) Dätgen Man (Germany)
17) Deby 29 (Poland)
18) Dejrø (Denmark)
19) Draved Forest (Germany)
20) Edewechterdamm (Germany)
21) Erkelenz-Kückhoven (Germany)
22) Feddersen-Wierde (Germany)
23) Flögeln (Germany)
24) Forchtenberg (Germany)
25) Friesack (Germany)
26) Fröslunda Bog (Sweden)
27) Grauballe Man (Denmark)
28) Grosses Moor (Germany): Trackway III (Pr); Trackway VI(Pr])
29) Grube-Rosenhof (Germany)
30) Halsskov Overdrev (Denmark)
31) Hendriksmose (Denmark)
32) Hindby bog (Sweden)
33) Hjortspring (Denmark)
34) Holmegårds Bog (Denmark)
35) Hove Å (Denmark)
36) Hüde 1 (Germany)
37) Hunte 1 (Germany)
38) Illerup (Denmark)
39) Ipwege Moor (Germany): Trackway XXV (Ip); Trackway XXX(Ip])
40) Jäckleberg (Huk, Orth & Nord) (Germany)
41) Kalø Vig I (Denmark)
42) Kappeln (Germany)
43) Kayhausen Boy (Germany)
44) Kuiavia (Poland)
45) Lake Hornborgarsjön (Sweden)
46) Lake Tingstäde (Sweden)
47) Lengener Moor (Germany): Ockenhausen/Oltmannsfehn; Trackway IX(Le); Trackway XVIII (Le)
48) Lundby bog (Denmark)
49) Mainz Romano-Celtic boat (Germany)
50) Mjölby area (Sweden)
51) Møllegabet I & II (Denmark)
52) Moora Girl (Germany)
53) Motala (Sweden)
54) Nieuw-Dorecht Moor (the Netherlands)
55) Nydam (Denmark)
56) Oberdorla (Germany)
57) Øgårde (Denmark)
58) Oldenburg-Dannau (Germany)
59) Öresund Strait (Sweden)
60) Pesse (Denmark)
61) Rendswühren Man (Germany)
62) Roter Franz (Germany)
63) Rude-Eskildstrup (Denmark)
64) Rügen Island (Germany)
65) Schöningen (Germany)
66) Schweger Moor (Germany): Trackway XXV(Pr)
67) Siggeneben-Süd (Germany)
68) Skedemosse (Sweden)
69) Slätteröd (Sweden)
70) Tågerup (Sweden)
71) Thumby (Germany)
72) Tibirke (Denmark)
73) Timmendorf-Nordmole I & II (Germany)
74) Tollund Man (Denmark)
75) Tybrind Vig (Denmark)
76) Wackershofen (Germany)
77) Wangels LA 505 (Germany)
78) Weerdinge Couple (the Netherlands)
79) Willemstad (the Netherlands)
80) Windeby Girl (Germany)
81) Wittemoor (Germany): Trackway XII; Trackway XLII
82) Xanten Romano-Celtic boat (Germany)
83) Yde Girl (Germany)
84) Zweeloo Woman (Germany)


16
22
24
2
12
10
34
21
27
1
15
8
30
33
23
3
31
18
25
29
14
6
32
26
19
17
4
11
36
20
7
35
28
5
13
9
1C
0
200
km

Map 1C

(Belarus, Estonia, Finland, Latvia, Lithuania, Poland, Russia)

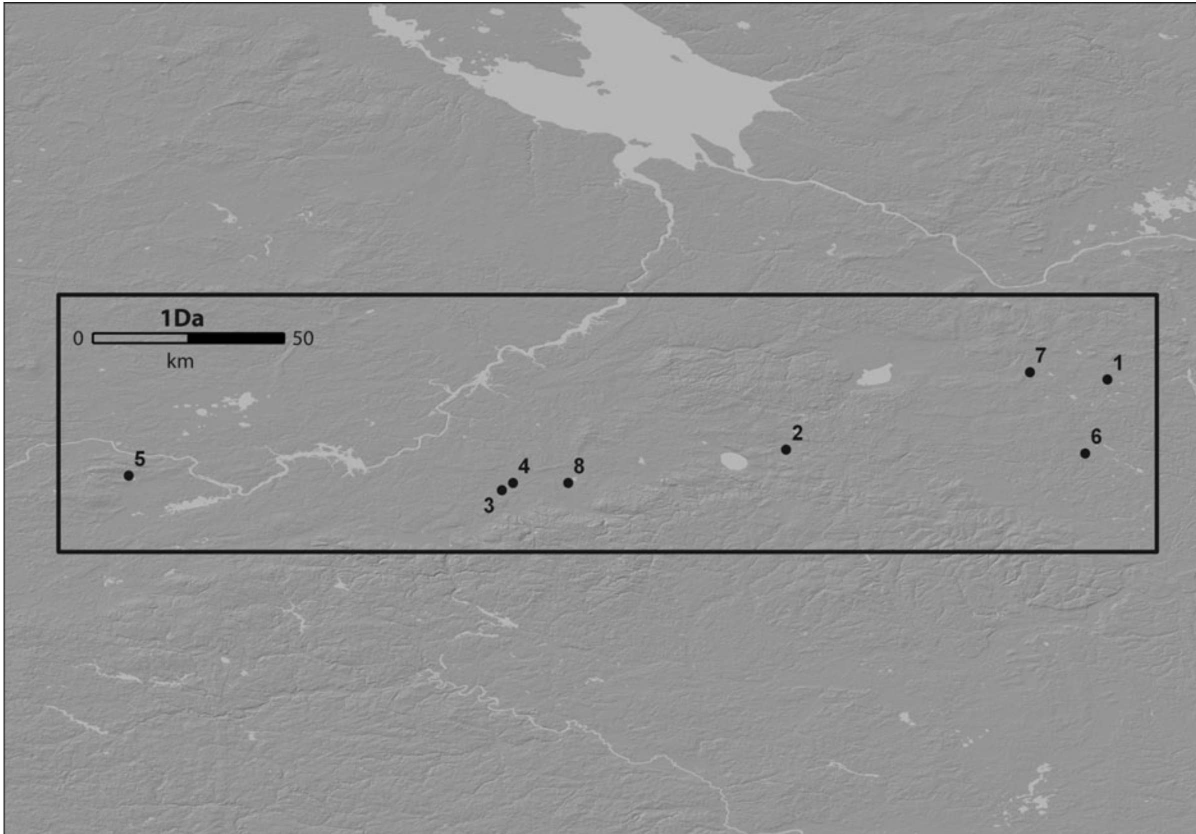
1) Akali (Estonia)
2) Antrea (Russia)
3) Āraiši (Latvia)
4) Asaviec (Belarus)
5) Aziarnoye 2B (Belarus)
6) Dubokrai (Russia)
7) Dudka (Poland)
8) Kääpa (Estonia)
9) Kamen 8 (Belarus)
10) Kõpu (Estonia)
11) Kryvina peatbog (Belarus)
12) Kunda (Estonia)
13) Kuzmichy 1 (Belarus)
14) Lake Biržulis (Lithuania)
15) Lake Koorküla-Valgjärv (Estonia)
16) Lake Korttajarvi (Finland)
17) Lake Kretuonas (Lithuania)
18) Lake Lubana (Latvia)
19) Lake Luokesas (Lithuania)
20) Moltajny (Poland)
21) Pulli (Estonia)
22) Ristola (Finland)
23) Ruhnu (Estonia)
24) Saarenoja 2 (Finland)
25) Sarnate (Latvia)
26) Serteya 2 (Russia)
27) Sindi-Lodja I (Estonia)
28) Sosnia (Poland)
29) Šventoji (Lithuania)
30) Tamula 1 (Estonia)
31) Ušuru (Latvia)
32) Usvyaty 4 (Russia)
33) Villa I (Estonia)
34) Võhma I (Estonia)
35) Woznia Wies (Poland)
36) Zacennie (Belarus)



1
2
1D
0
200
km

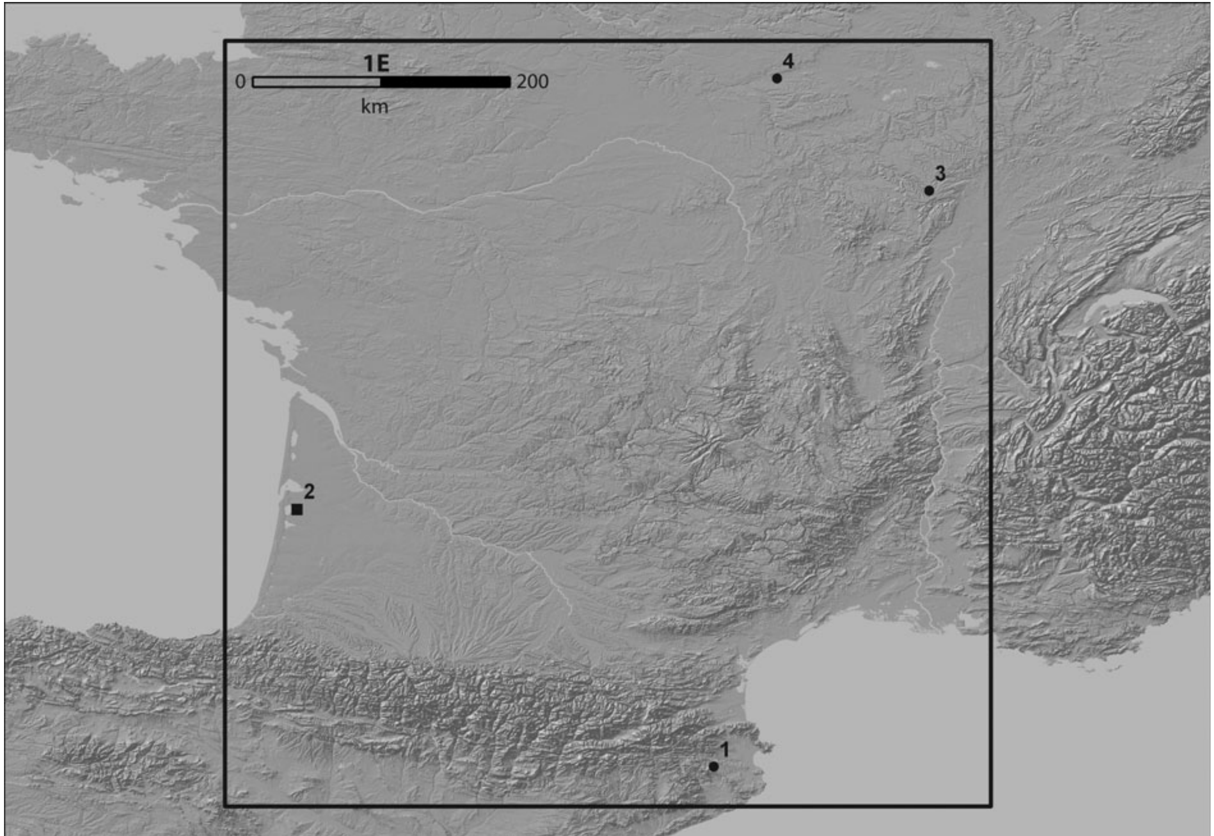
Map 1D
(North-western Russia)

1) Nizhneye Veretye (Russia)
2) Vis I & II (Russia)


1Da
0
50
km
1
2
3
4
5
6
7
8

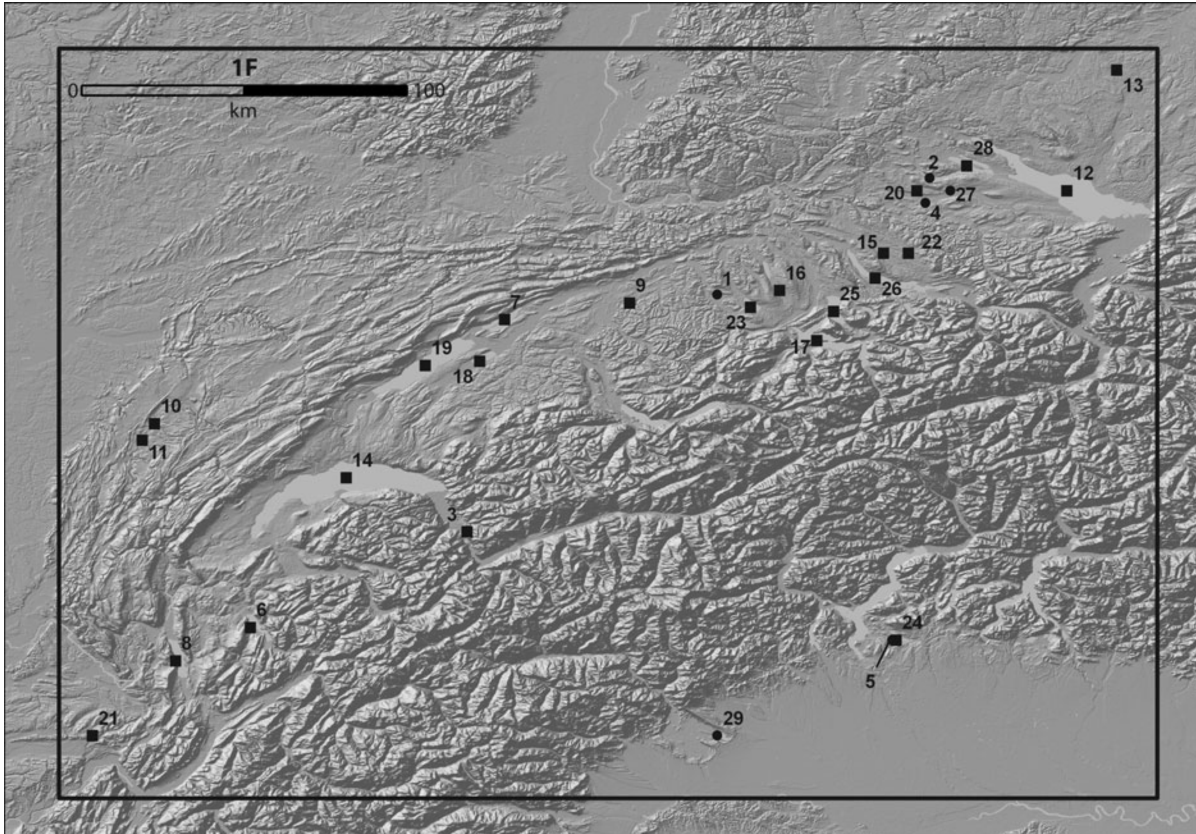
Map 1Da
(North-western Russia—Volga region)

1) Butovo (Russia)
2) Ivanovskoje 7 (Russia)
3) Nushpoli 11 (Russia)
4) Okajomovo 5 (Russia)
5) Ozerki 5, 16, 17 (Russia)
6) Sakhtysh (Russia)
7) Stanovoje 4 (Russia)
8) Zamostje 2 (Russia)


1E
0
200
km
1
2
3
4

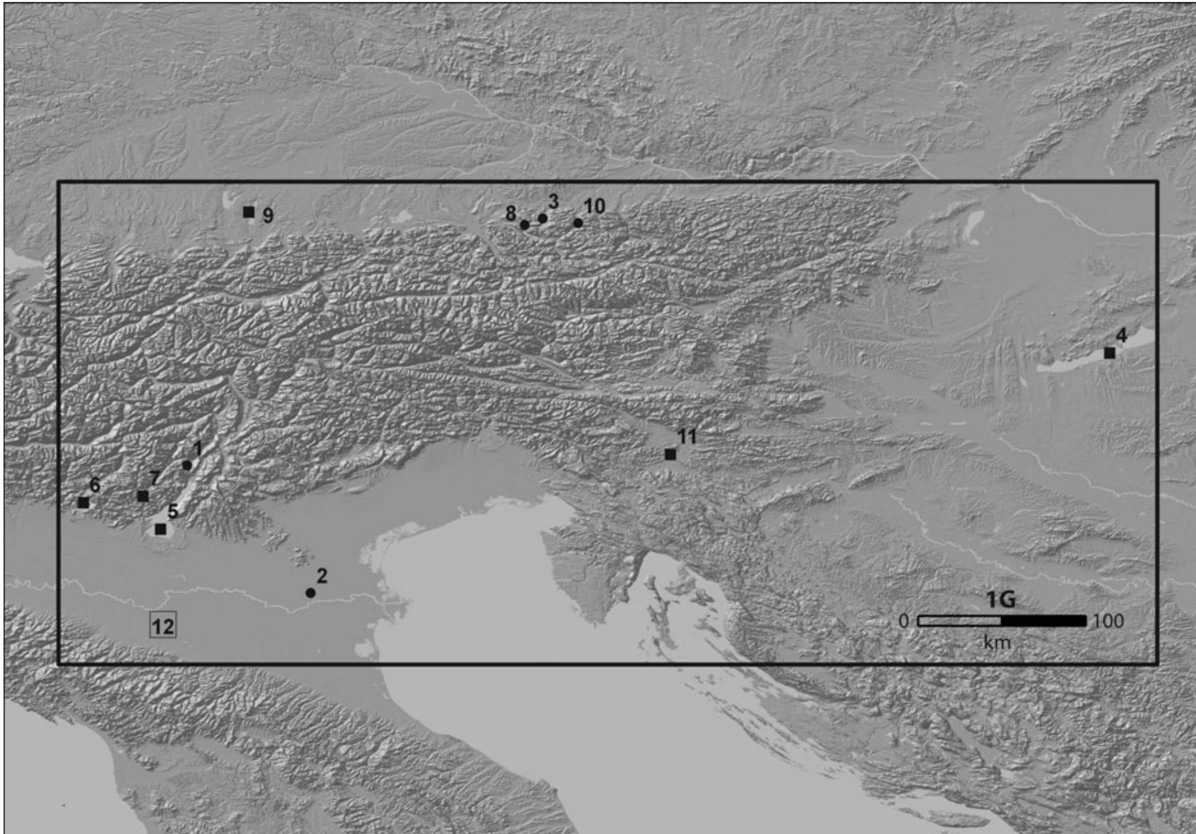
Map 1E
(France, Spain)

1) La Draga (Spain)
2) Lake Sanguinet (France): De Losa; L'Estey du Large; Put Blanc
3) Les Sources de la Seine (France)
4) Noyen-Sur-Seine (France)


1F
0
100
km
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29

Map 1F
(France, Germany, Italy, Switzerland)

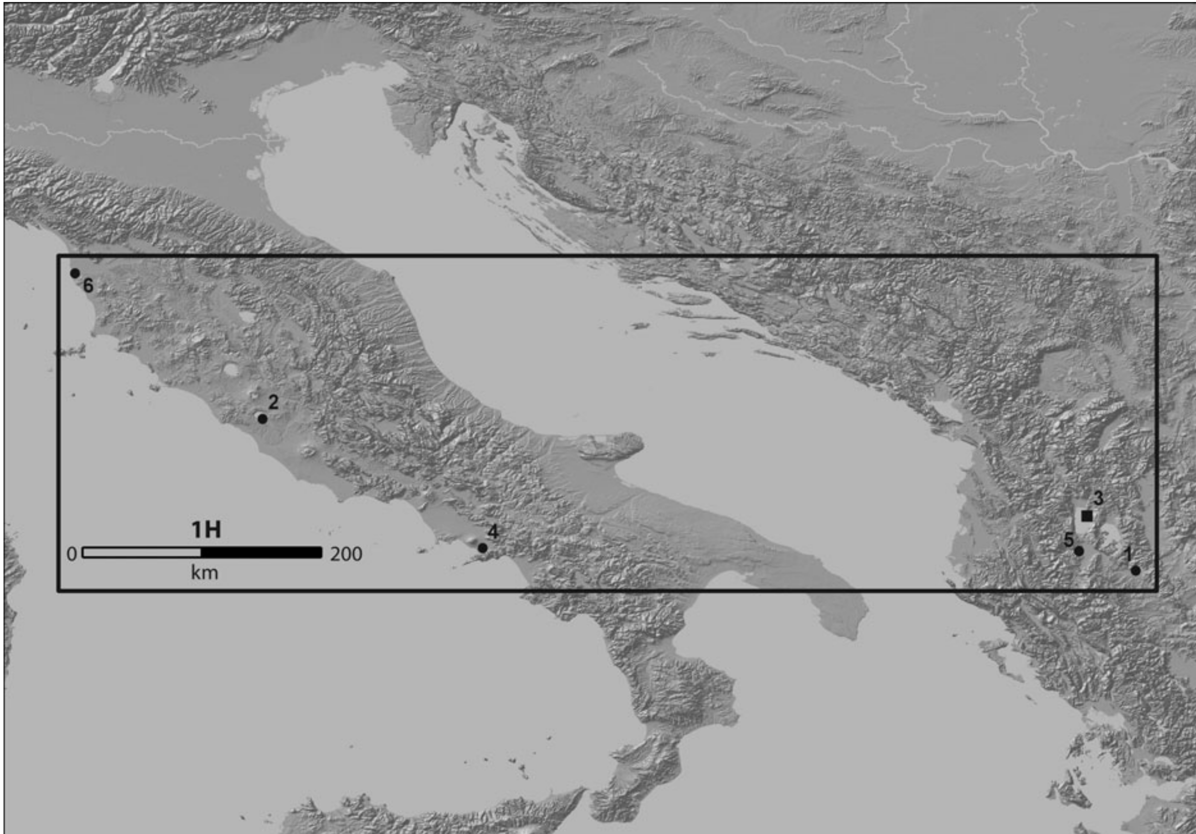
1) Egolzwil (Switzerland)
2) Eschenz-Tasgetium (Switzerland)
3) Former Lake Luissel (Switzerland)
4) Gachnang-Niederwil (Switzerland)
5) Isolino Virginia (Italy)
6) Lake Annecy (France)
7) Lake Biel (Switzerland): Nidau; Sutz-Lattrigen-Hauptstation; Sutz-Lattrigen-Kleine Station; Sutz-Lattrigen-Riedstation; Sutz-Lattrigen-Rütte; Twann
8) Lake Bourget (France)
9) Lake Burgäschi (Switzerland)
10) Lake Chalain (France): Chalain
11) Lake Clairvaux (France)
12) Lake Constance (Switzerland/Germany): Allensbach (Untersee, Germany); Arbon-Bleiche 3 (Switzerland); Bodman-Schachen 1 (Germany); Ermatingen (Untersee, Switzerland); Hornstaad-Hörnle 1A & 1B (Untersee, Germany); Ludwigshafen-Seehalde (Germany); Nussdorf-Strandbad (Germany); Sipplingen-Osthafen (Germany); Steckborn-Schanz (Untersee, Switzerland); Wangen-Hinterhorn (Untersee, Germany)
13) Lake Feder (Federsee) (Germany): Aichbühl; Dullenried; Oggelshausen-Bruckgraben; Reute-Schorrenried; Seekirch-Achwiesen; Seekirch-Stockwiesen; Wasserburg-Buchau
14) Lake Geneva (Switzerland/France): Morges (Switzerland)
15) Lake Greifen (Switzerland): Greifensee-Böschen
16) Lake Hallwil (Switzerland): Hitzkirch
17) Lake Lucern (Switzerland)
18) Lake Morat (Switzerland): Greg
19) Lake Neuchâtel (Switzerland): Auvernier; Auvernier La Saunerie; Bevaix boat; Concise; Estavayer; Hauterive-Champréveyres; Marin-Les-Piécelettes; Petit Cortaillod; Saint Blaise-Bains; St Blaise; Yverdon boat
20) Lake Nussbaum (Switzerland): Ürschhausen-Horn
21) Lake Paladru (France): Charavives-Colletière; Les Baigneurs
22) Lake Pfäffikon (Switzerland): Wetzikon-Robenhausen
23) Lake Sempach (Switzerland)
24) Lake Varese (Italy): Isolino Virginia
25) Lake Zug (Switzerland): Cham-Eslen; Oberrisch-Aabach; Steinhausen-Chollerpark; Zug-Schützenmatt; Zug-Sumpf
26) Lake Zurich (Switzerland): Rapperswil; ZH-Grosser Hafner; ZH-KanSan; ZH-Kleine Hafner; ZH-Mozartstrasse; ZH-Mythenschloss; ZH-Opera car park; ZH-Seefeld
27) Pfyn-Breitenloo (Switzerland)
28) Untersee (see Lake Constance) (Switzerland/Germany)
29) Viverone (Italy)



9
8
3
10
4
11
1
6
7
5
2
12
1G
0
100
km

Map 1G
(Austria, Hungary, Italy, Slovenia)

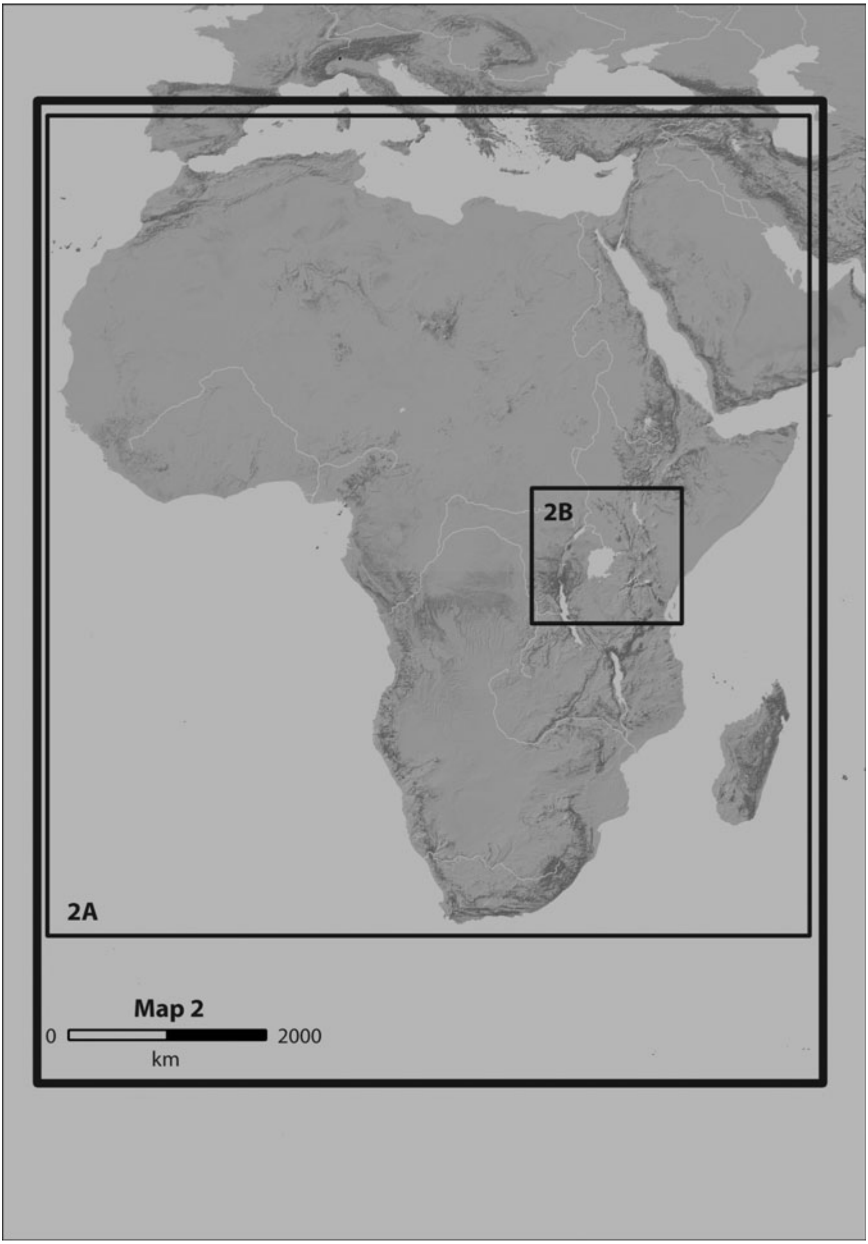
1) Fiavé (Italy)
2) Frattesina (Italy)
3) Lake Atter (Austria)
4) Lake Balaton (Hungary)
5) Lake Garda (Italy)
6) Lake Iseo (Italy)
7) Lake Ledro (Italy)
8) Lake Mond (Austria)
9) Lake Starnberg (Germany): Bernried dugout; Roseninsel
10) Lake Traun (Austria)
11) Ljubljana Marsh (Slovenia): Resnikov Prekop
12) Terramare Area (Italy): Ca' de' Cessi; Castione dei Marchesi; Montale; Poggio Rusco; S. Rosa di Poviglio



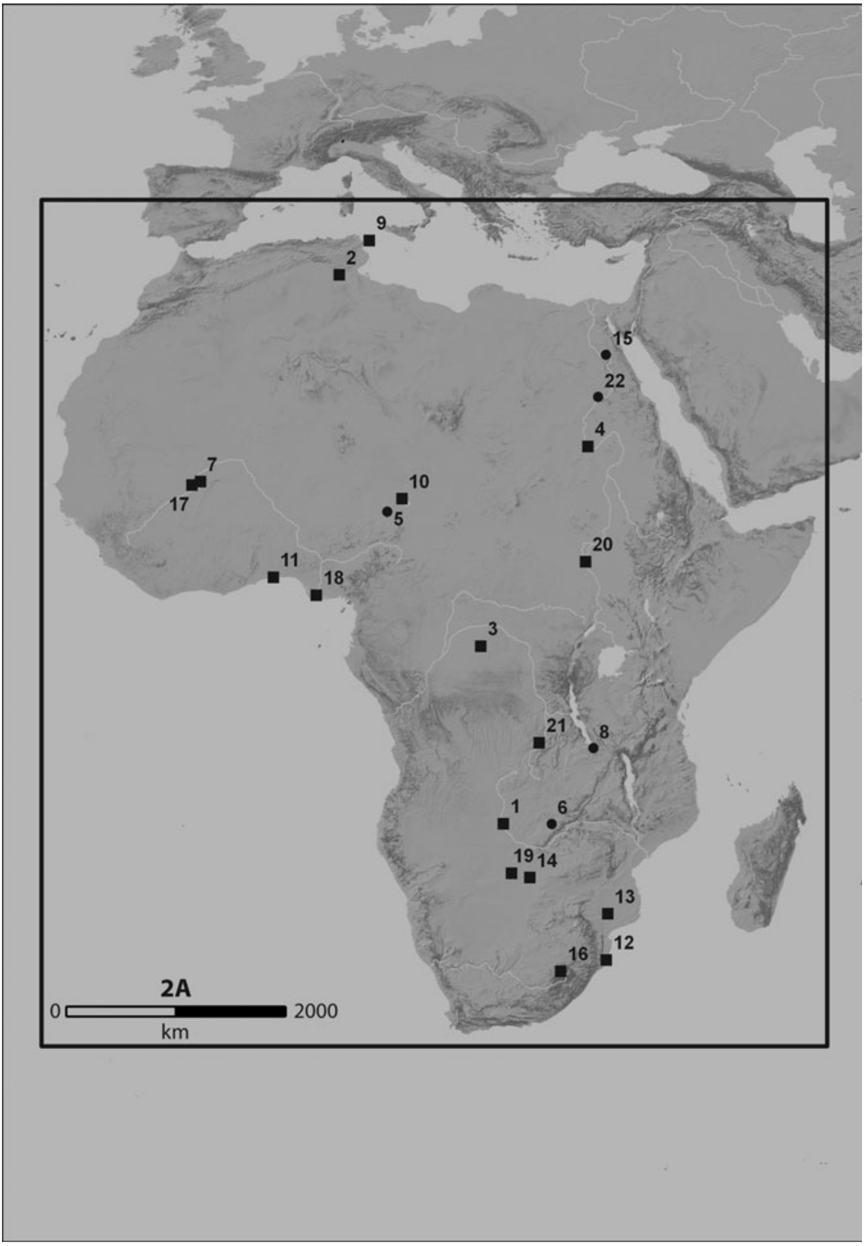
6
2
4
3
5
1
1H
0
200
km

Map 1H
(Albania, Greece, Italy, Macedonia)

1) Dispilio (Greece)
2) La Marmotta (Italy)
3) Lake Ohrid (Macedonia/Albania)
4) Poggiomarino (Italy)
5) Sovian (Albania)
6) Stagno (Italy)


2B
2A
Map 2
0
2000
km

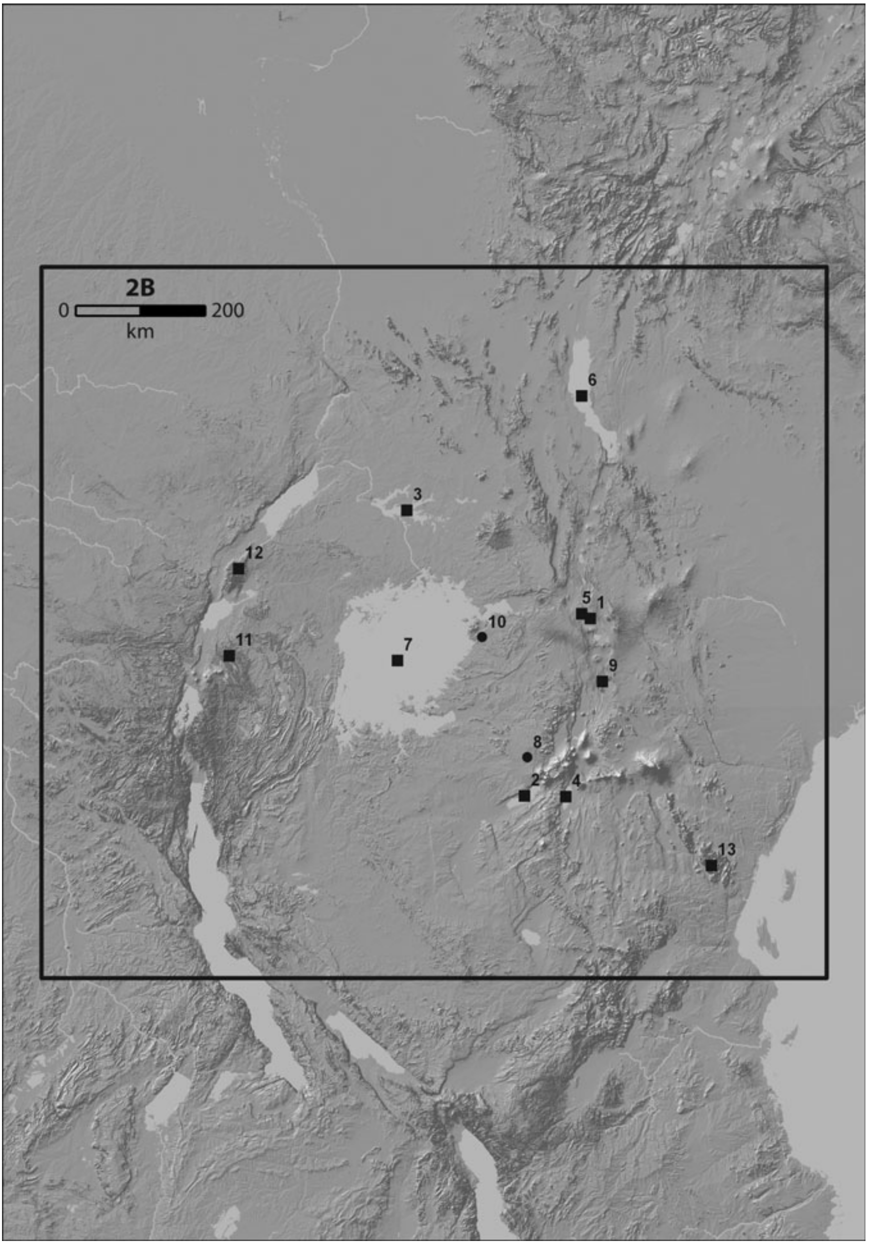
Map 2: Africa
Map 2A (Benin, Botswana, Cameroon, Chad, Congo DRC, Egypt, Lesotho, Mali, Mozambique, Niger, Nigeria, South Africa, Sudan, Tunisia, Zambia)
Map 2B (Ethiopia, Kenya, Tanzania, Uganda)


9
2
15
22
4
7
17
10
5
20
11
18
3
21
8
1
6
19
14
13
12
16
2A
0
2000
km

Map 2A

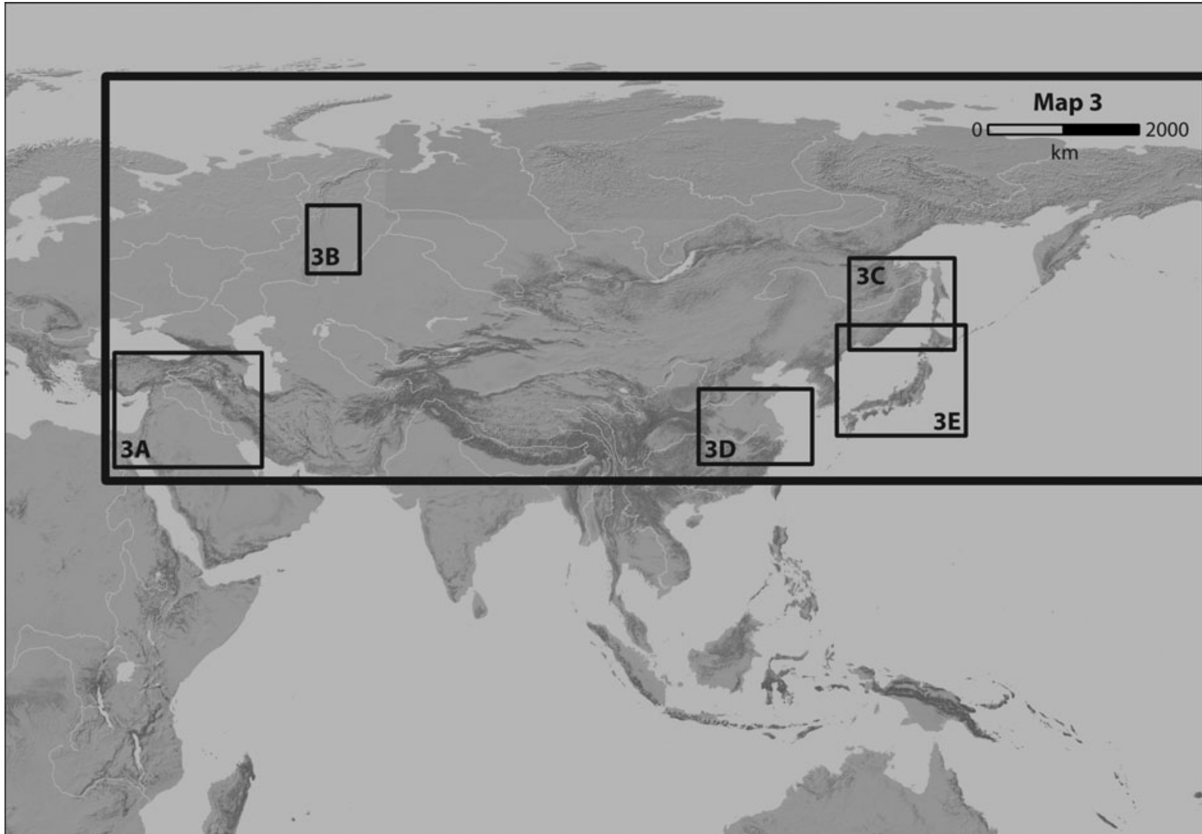
(Benin, Botswana, Cameroon, Chad, Congo DRC, Egypt, Lesotho, Mali, Mozambique, Niger, Nigeria, South Africa, Sudan, Tunisia, Zambia)

1) Barotse Plain (Zambia)
2) Chott Djerid (Tunisia)
3) Congo Basin (Congo DRC)
4) Dongola Reach (Sudan)
5) Dufuna (Nigeria)
6) Gwisho Hotsprings (Zambia)
7) Inland Niger Delta (Mali)
8) Kalambo Falls (Zambia)
9) Korba Lagoons (Tunisia)
10) Lake Chad (Chad/Nigeria/Niger/Cameroon)
11) Lake Naboue (Benin)
12) Lake St Lucia (South Africa)
13) Limpopo River Basin (Mozambique)
14) Makgadikgadi saltpans (Botswana)
15) Makhadma 2 & 4 (Egypt)
16) Maloti Mountains (Lesotho)
17) Mema Basin (Mali)
18) Niger Delta (Nigeria)
19) Okavango Basin (Botswana)
20) Sudd swamps (Sudan)
21) Upemba Depression (Congo DRC)
22) Wadi Kubbaniya (Egypt)

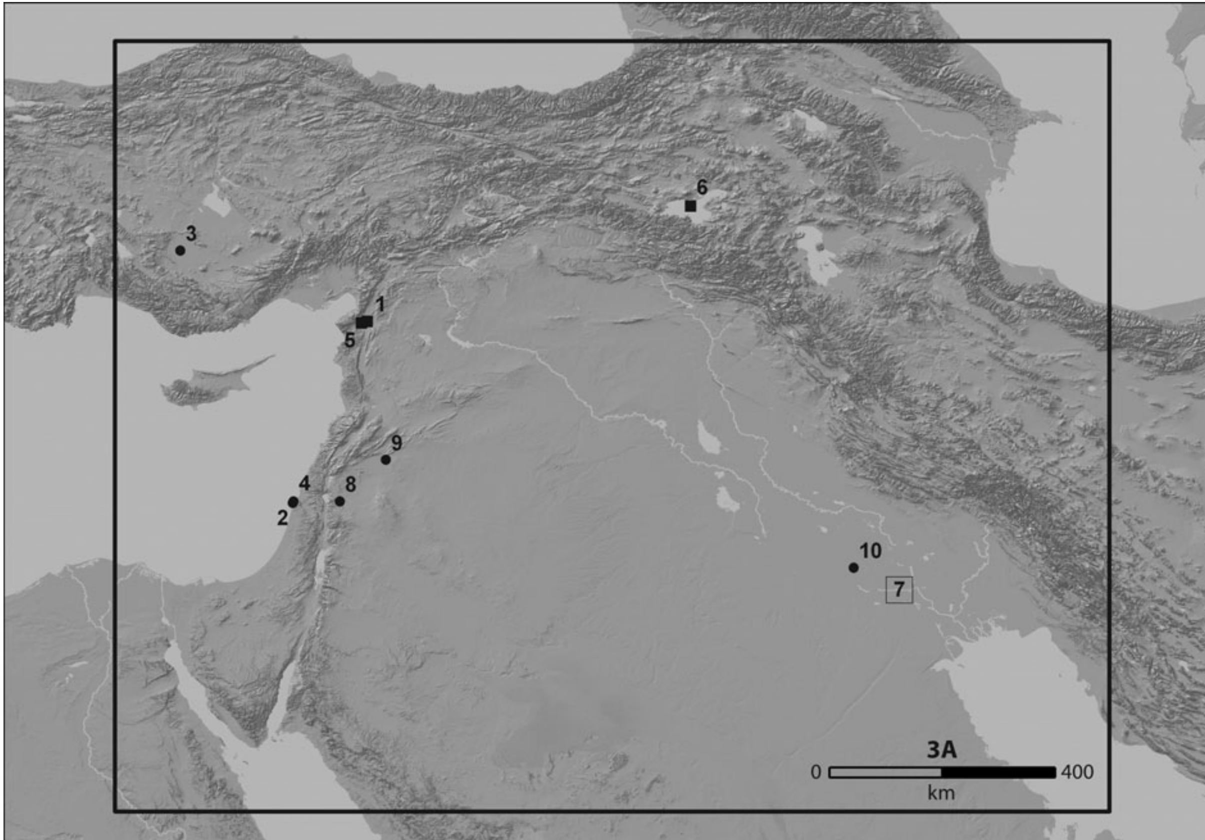

2B
0
200
km
1
2
3
4
5
6
7
8
9
10
11
12
13

Map 2B
(Ethiopia, Kenya, Tanzania, Uganda)

1) Lake Elmenteita (Kenya)
2) Lake Eyasi (Tanzania)
3) Lake Kyoga (Uganda)
4) Lake Manyara (Kenya)
5) Lake Nakuru (Kenya)
6) Lake Turkana (Kenya/Ethiopia)
7) Lake Victoria (Uganda/Tanzania/Kenya)
8) Olduvai Gorge (Tanzania)
9) Olorgesailie (Kenya)
10) Pundo (Kenya)
11) Rukiga Highlands (Uganda)
12) Ruwenzori range (Uganda)
13) Usambara ranges (Tanzania)


Map 3
0
2000
km
3A
3B
3C
3D
3E

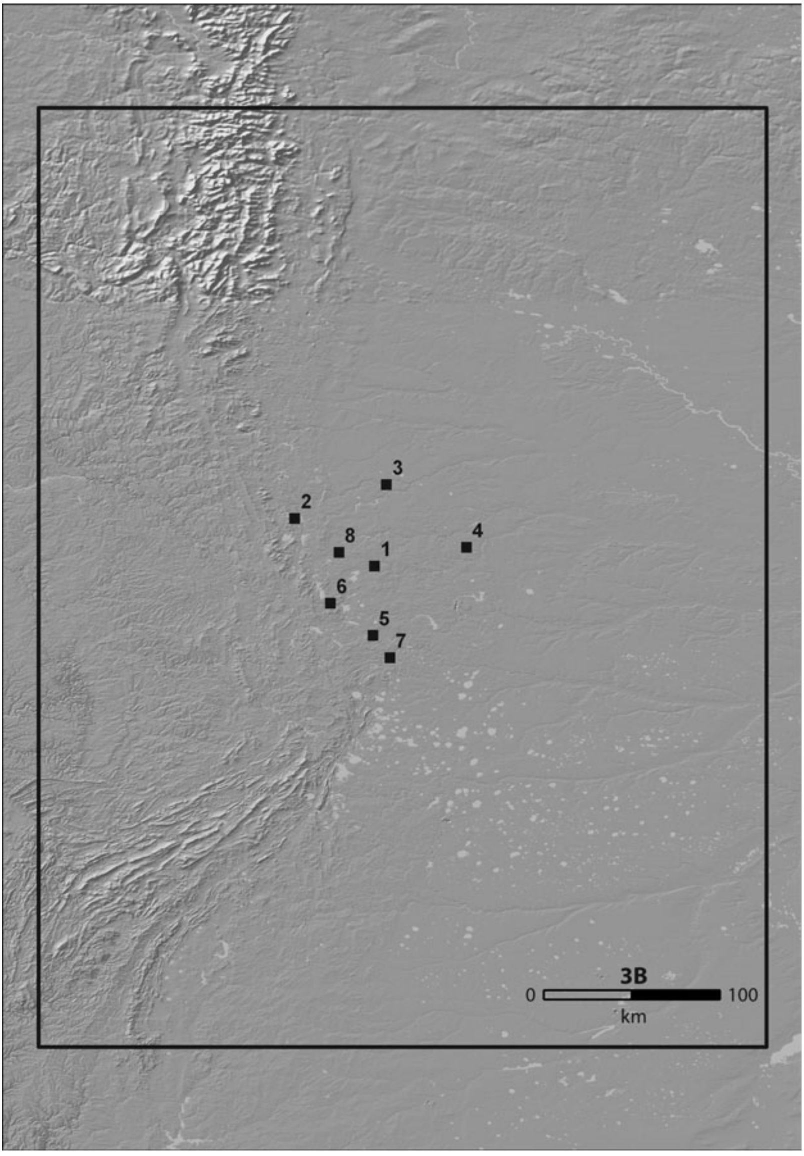
Map 3: Asia



1
2
3
4
5
6
7
8
9
10
3A
0
400
km

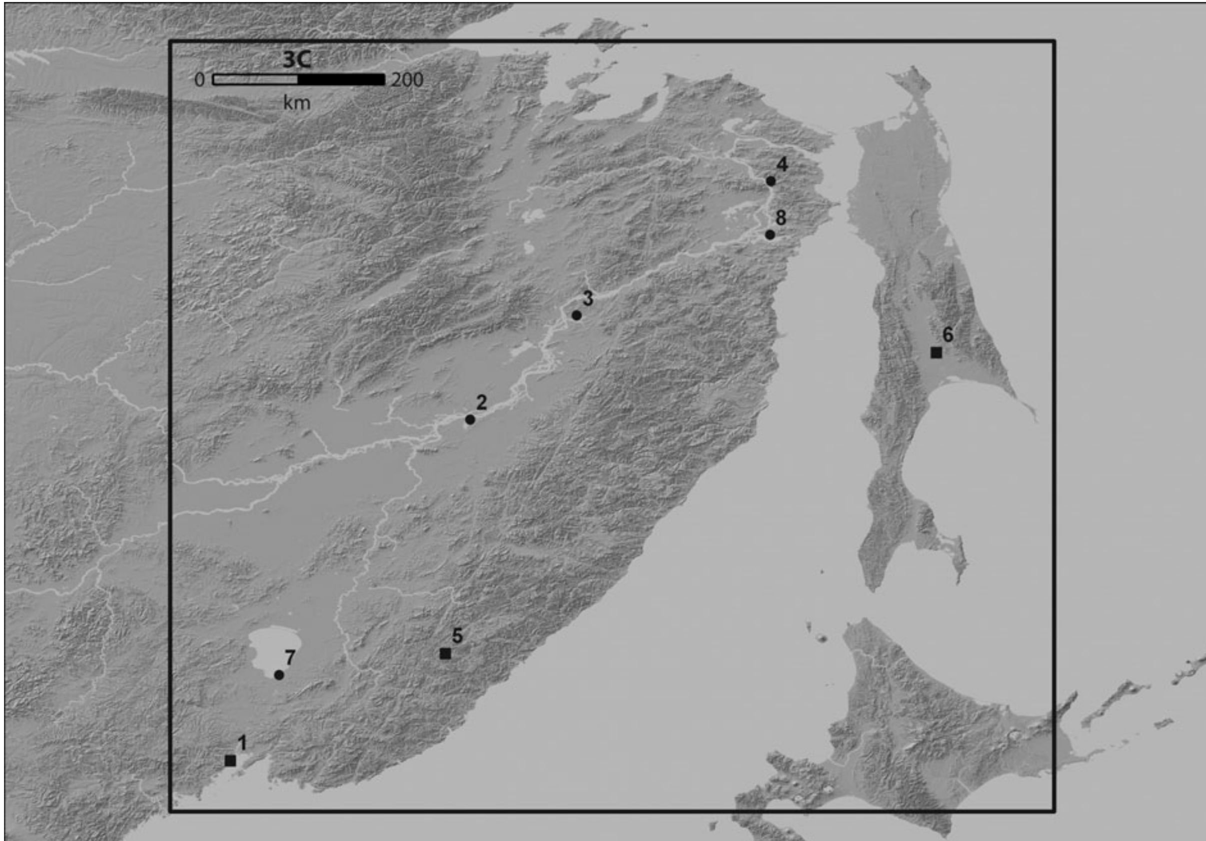
Map 3A
(Middle East: Iraq, Israel, Syria, Turkey)

1) Amuq Plain (Turkey)
2) Atlit Yam (Israel)
3) Çatal Höyük (Turkey)
4) Kafar Samir (Israel)
5) Lake Antioch (Turkey)
6) Lake Van (Turkey)
7) Marsh Arabs (Iraq)
8) Ohalo (Israel)
9) Tell Aswad (Syria)
10) Tell Oueli (Iraq)


3
2
8
1
4
6
5
7
3B
0
100
km

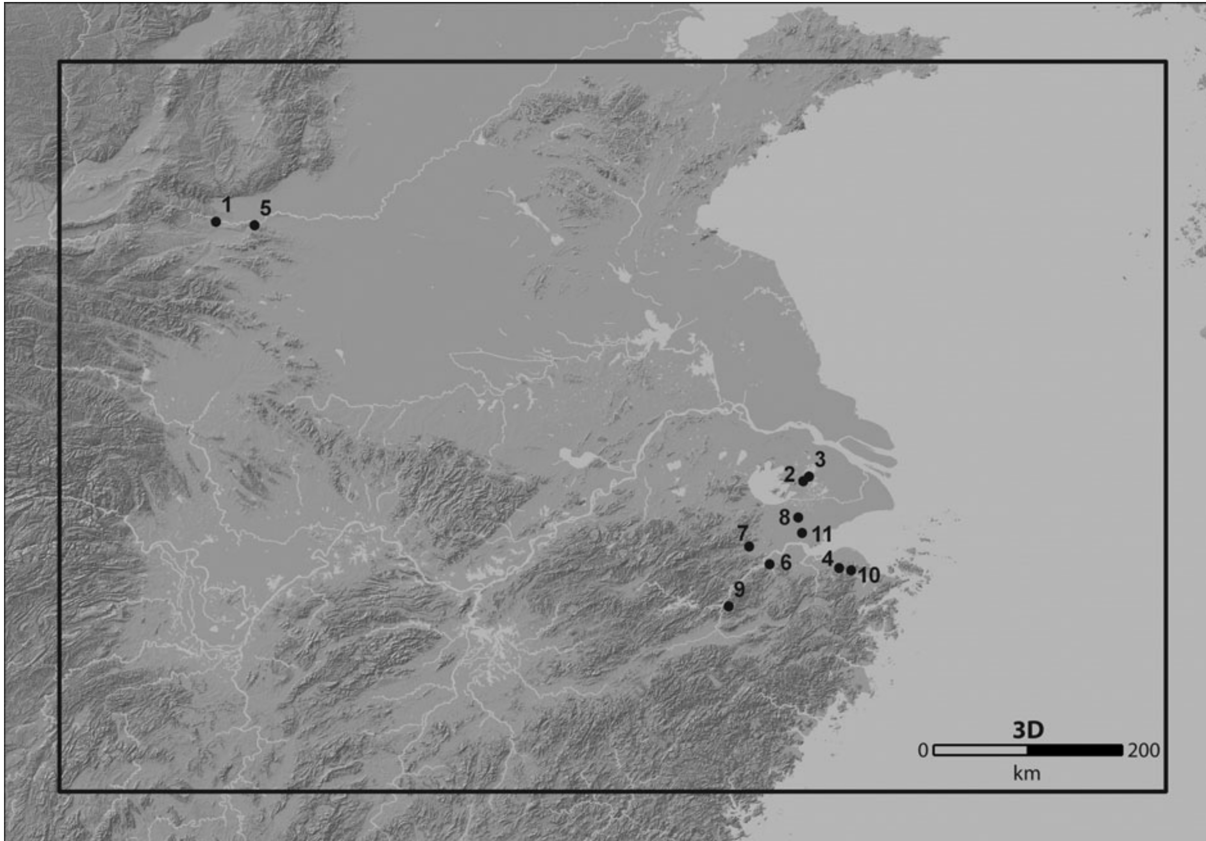
Map 3B
(Russia: Middle Urals)

1) Ayatskoe Moor (Russia)
2) Gorbunovo Moor (Russia)
3) Koksharovskoy Moor (Russia)
4) Lake Moltaevo (Russia)
5) Lake Pervoe Karasye (Russia)
6) Lake Shuvakish (Russia)
7) Lake Vtoroe Karasye (Russia)
8) Shigirsky Moor (Russia)


3C
0
200
km
1
2
3
4
5
6
7
8

Map 3C
(Russian Far East)

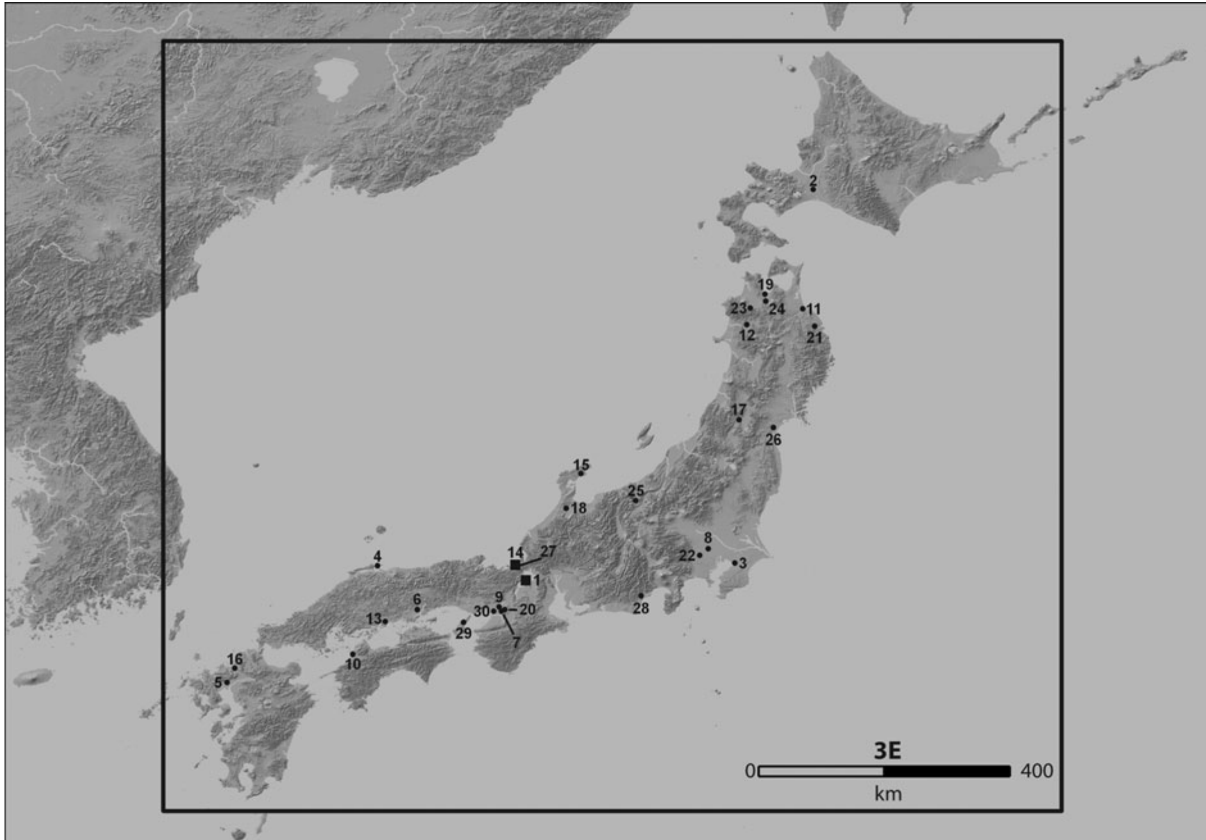
1) Boisman Bay (Russia)
2) Gasya (Russia)
3) Khummi (Russia)
4) Malaya Gavan (Russia)
5) Primorye (Russia)
6) Sakhalin Island (Russia)
7) Sinii Gai (Russia)
8) Suchu (Russia)



1
5
3
2
8
11
7
6
4
10
9
3D
0
200
km

Map 3D
(China)

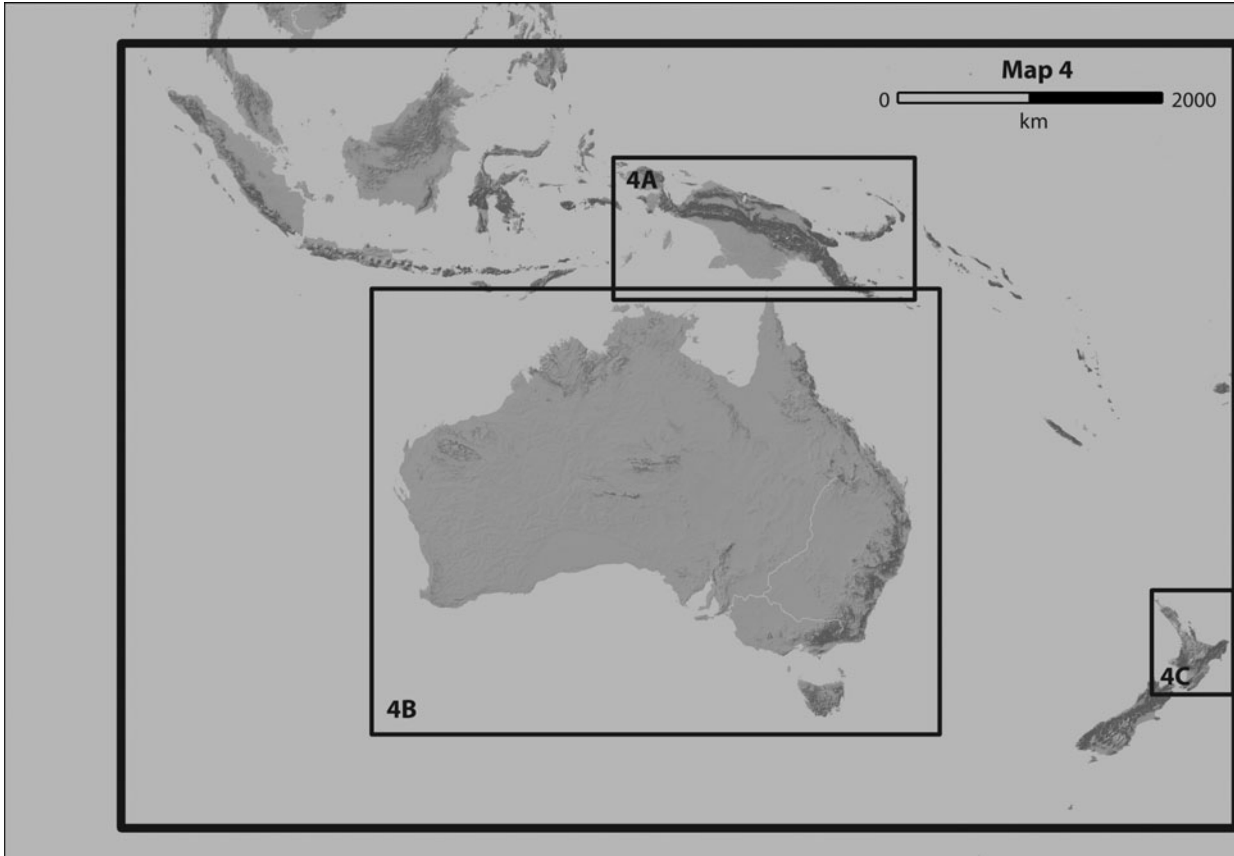
1) Banbo (China)
2) Caoxieshan (China)
3) Choudeng (China)
4) Hemudu (China)
5) Jiangzhai (China)
6) Kuahuqiao (China)
7) Liangzhu (China)
8) Majiabang (China)
9) Shangshan (China)
10) Tianluoshan (China)
11) Xiantaimiao (China)



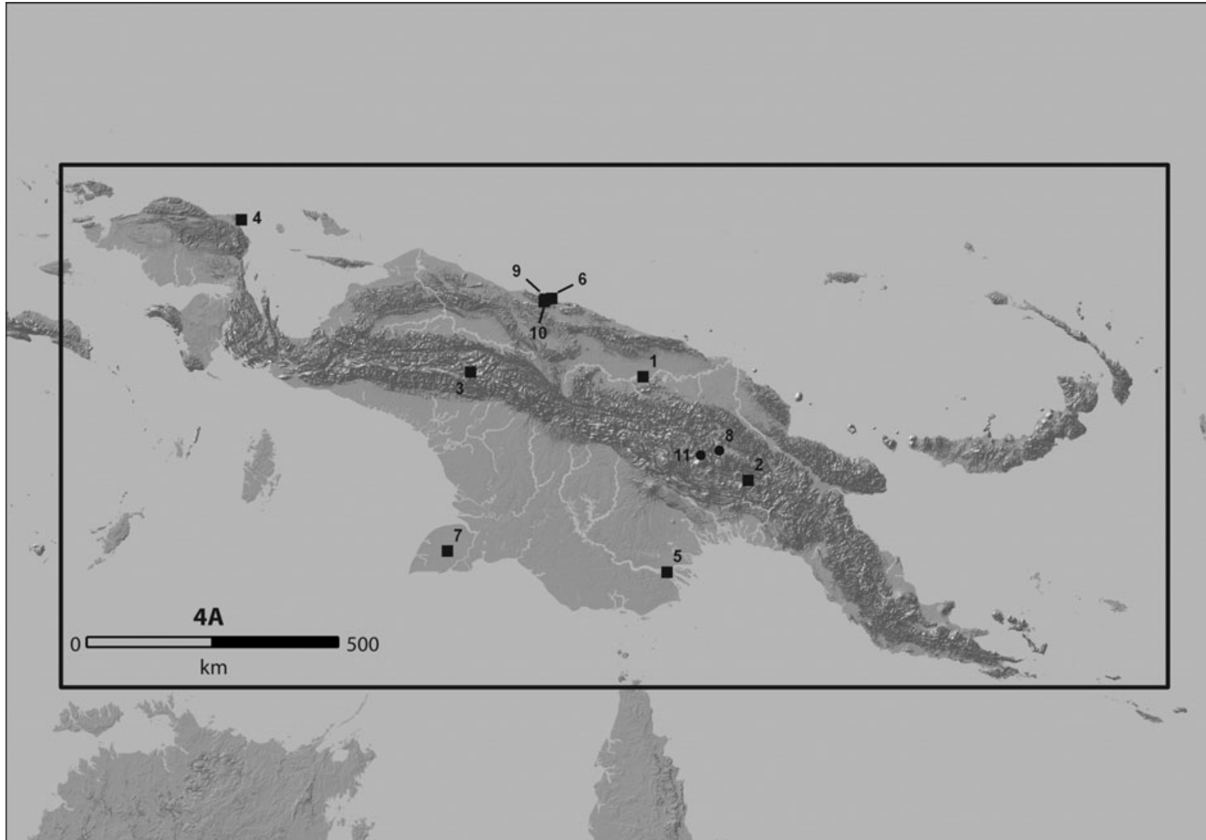
2
19
23
24
11
12
21
17
26
15
25
18
8
22
3
4
14
27
1
6
9
30
20
13
29
7
28
16
10
5
3E
0
400
km

Map 3E
(Japan)

1) Awazu (Lake Biwa) (Japan)
2) Bibi 8 (Japan)
3) Chiba logboat (Japan)
4) Hashinawate 1 (Japan)
5) Higashimyo (Japan)
6) Hyakukengawa (Japan)
7) Ikejima-Fukumanji (Japan)
8) Juno (Japan)
9) Kamei (Japan)
10) Kodera (Japan)
11) Korekawa (Japan)
12) Kurumidate (Japan)
13) Kusado-sengen-cho (Japan)
14) Lake Suigetsu (Japan)
15) Mawaki (Japan)
16) Naka Kyuhira (Japan)
17) Ondashi (Japan)
18) Sakuramachi (Japan)
19) Sannai Maruyama (Japan)
20) Saragawa (Japan)
21) Shidanai (Japan)
22) Shimoyakebe (Japan)
23) Sunazawa (Japan)
24) Tareyanagi (Japan)
25) Tategahana (Japan)
26) Tomizawa (Japan)
27) Torihama Shell Midden (Japan)
28) Toro (Japan)
29) Tsukuda (Japan)
30) Yamaga (Japan)


Map 4
0
2000
km
4A
4B
4C

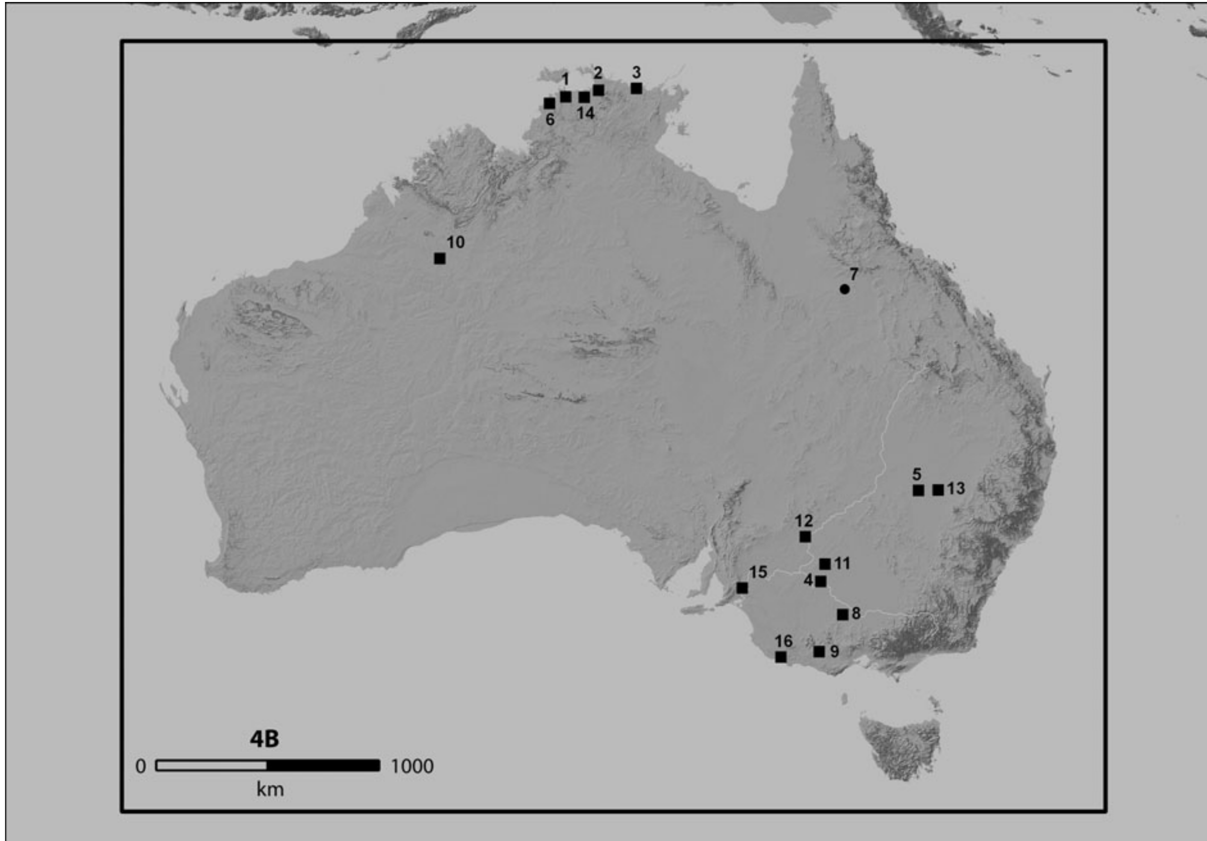
Map 4: Oceania
Map 4A (New Guinea: Irian Jaya [Indonesia], Papua New Guinea)
Map 4B (Australia)
Map 4C (New Zealand—*Aotearoa*)



4
9
6
10
1
3
8
11
2
7
5
4A
0
500
km

Map 4A
(New Guinea: Irian Jaya [Indonesia], Papua New Guinea)

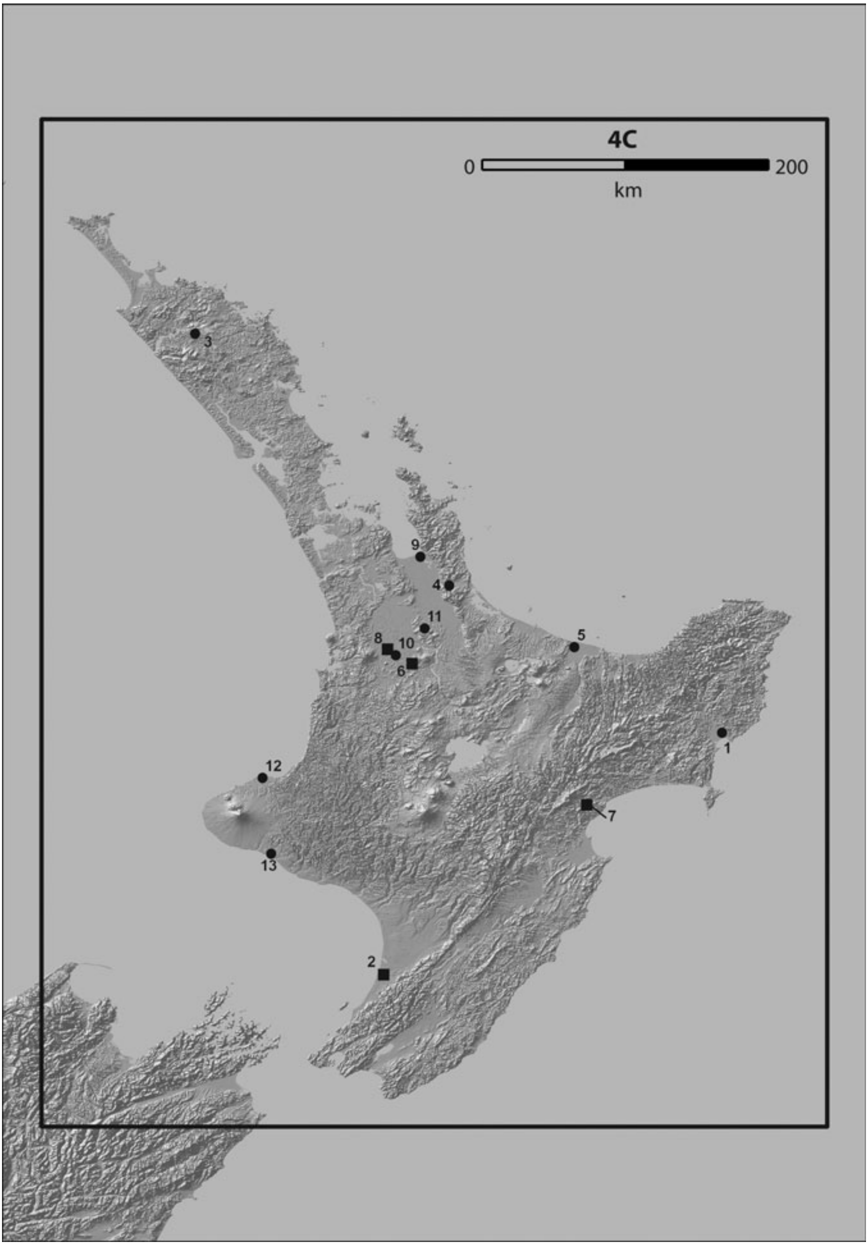
1) Amogu flooplains
2) Arona Valley
3) Baliem Valley
4) Doreh Bay
5) Fly estuary
6) Humboldt Bay
7) Kolepom Island
8) Kuk Swamp
9) Lake Hordorli
10) Lake Sentani
11) Tambul Swamp



1
2
3
6
14
10
7
5
13
12
11
15
4
8
16
9
4B
0
1000
km

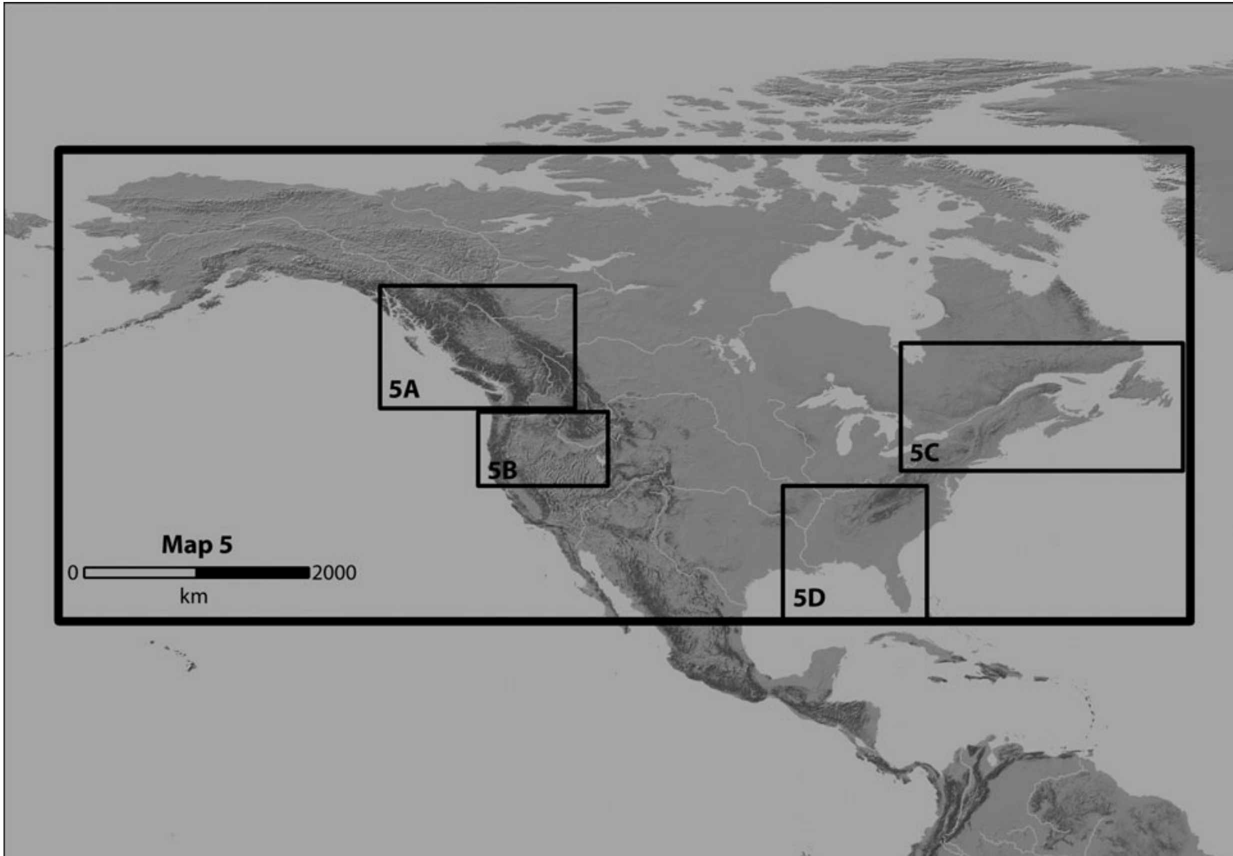
Map 4B
(Australia)

1) Adelaide River (Australia)
2) Alligator River (Australia)
3) Blyth River (Australia)
4) Coobool Creek (Australia)
5) Cuddie Springs (Australia)
6) Finniss River (Australia)
7) Kenniff Cave (Australia)
8) Kow Swamp (Australia)
9) Lake Bolac (Australia)
10) Lake Gregory (Australia)
11) Lake Mungo (Australia)
12) Lake Tandou (Australia)
13) Macquarie Marshes (Australia)
14) Mary River (Australia)
15) Roonka (Australia)
16) Wyrie Swamp (Australia)

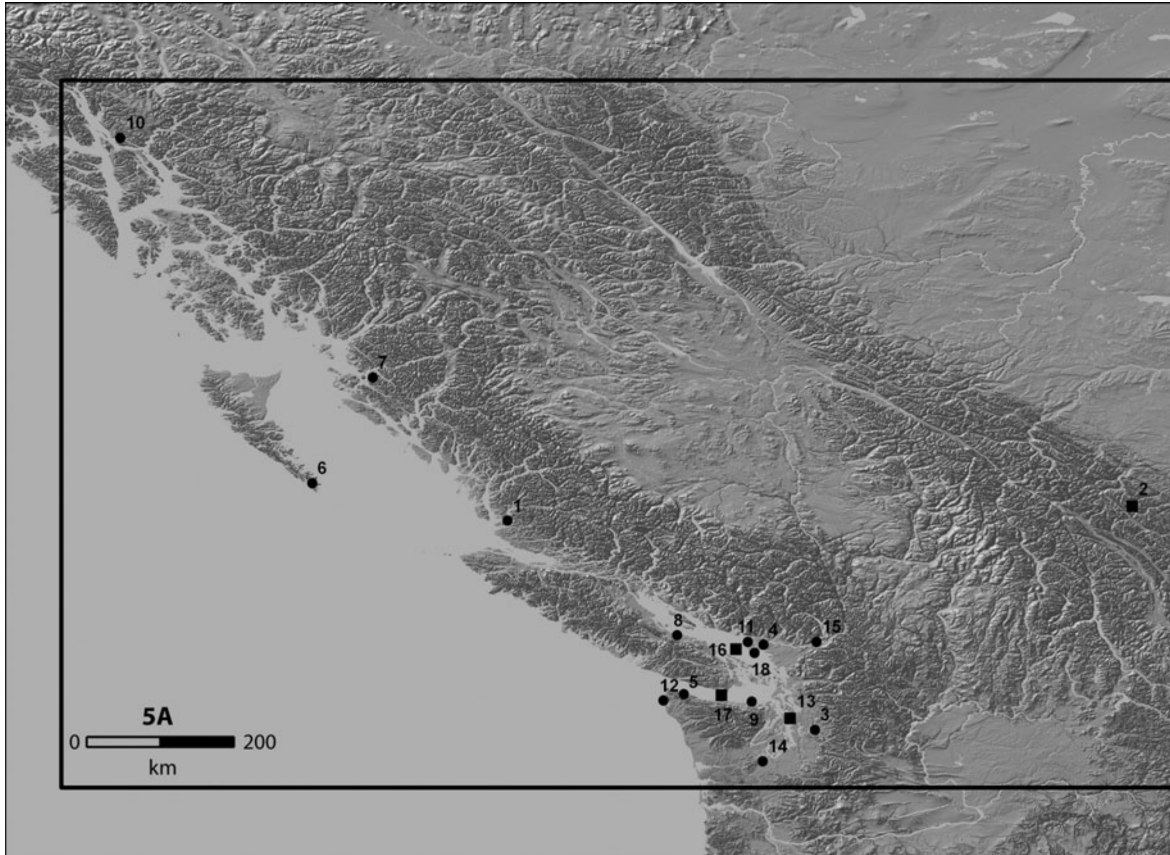

4C
0
200
km
1
2
3
4
5
6
7
8
9
10
11
12
13

Map 4C
(New Zealand—*Aotearoa*)

1) Gisborne (New Zealand)
2) Harowhenua (New Zealand)
3) Kaikohe (New Zealand)
4) Kauri Point (New Zealand)
5) Kohika (New Zealand)
6) Lake Ngaroto (New Zealand)
7) Lake Tutira (New Zealand)
8) Mangakaware (New Zealand)
9) Oruarangi (New Zealand)
10) Te Awamutu (New Zealand)
11) Te Miro (New Zealand)
12) Waitara (New Zealand)
13) Waitore (New Zealand)


5A
5B
5C
5D
Map 5
0
2000
km

Map 5: North America

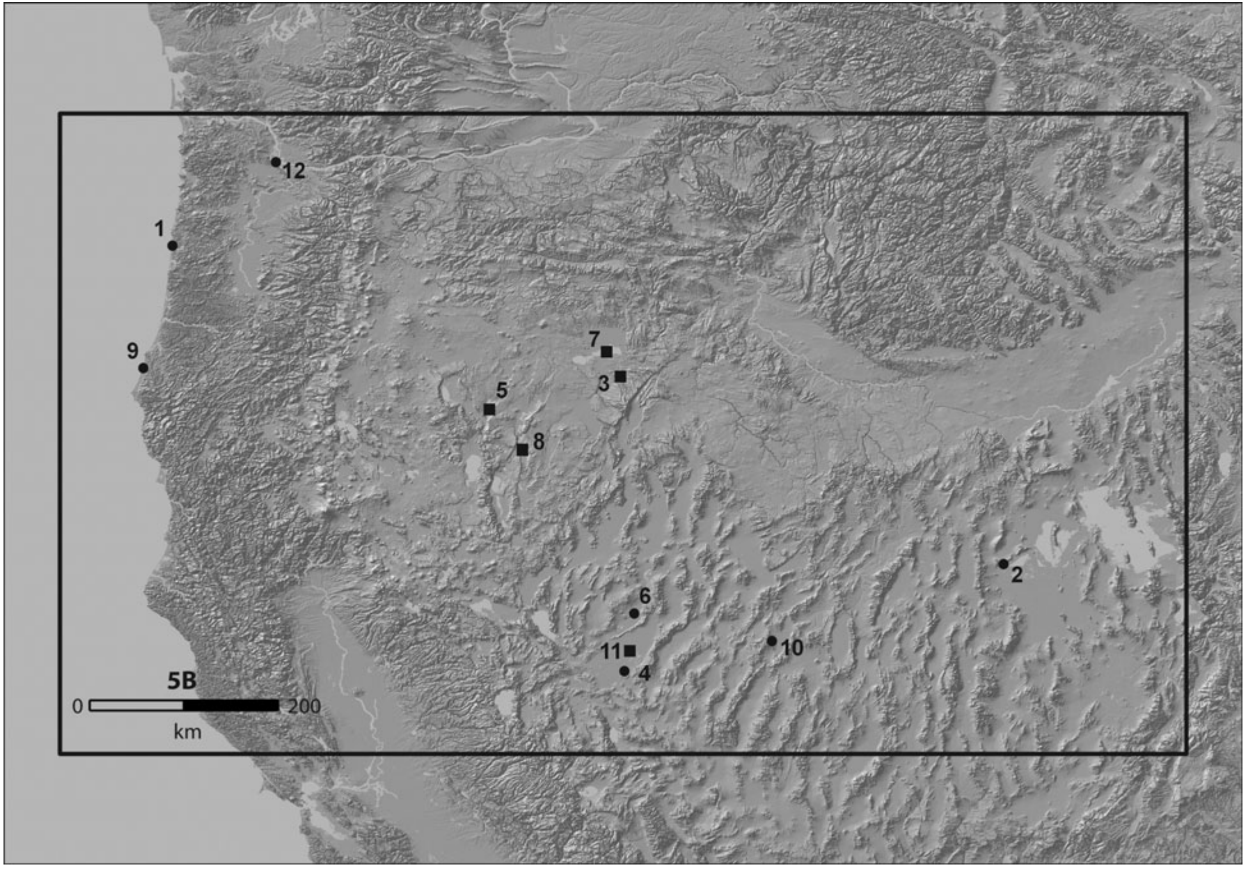


10
7
6
1
2
8
11
4
15
16
18
12
5
17
9
13
3
14
5A
0
200
km

Map 5A

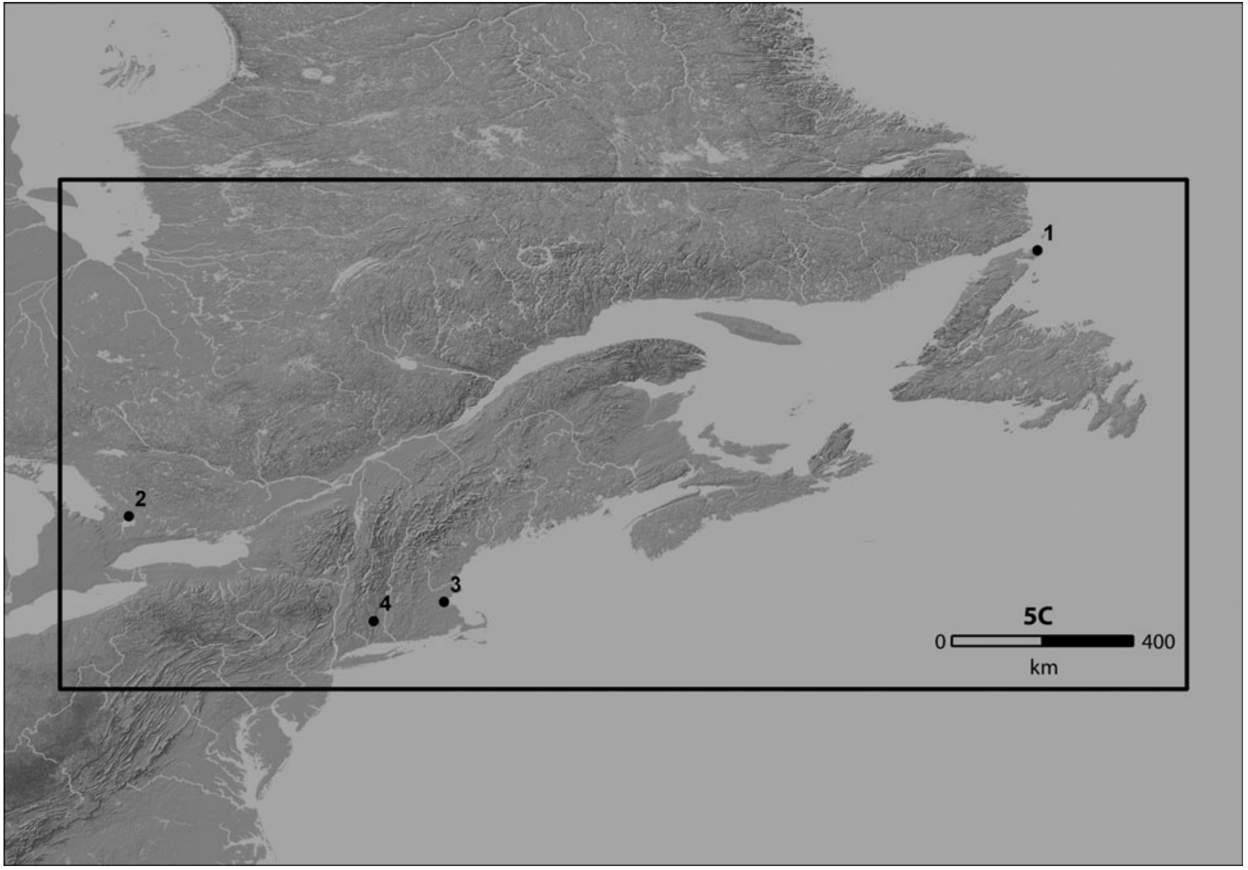
(Northwest Coast—Canada; Northwest Coast—United States)

1) Axeti (Canada)
2) Banff National Park (Canada)
3) Biederbost (United States)
4) Glenrose Cannery (Canada)
5) Hoko River (United States)
6) Kilgii Gwaai (Canada)
7) Lachane (Canada)
8) Little Qualicum River (Canada)
9) Manis Mastodon (United States)
10) Montana Creek (United States)
11) Mosqueam Northeast (Canada)
12) Ozette (United States)
13) Puget Sound (United States)
14) Qwu?gwes (United States)
15) Scowlitz (Canada)
16) Strait of Georgia (United States/Canada)
17) Strait of Juan de Fuca (United States/Canada)
18) Water Hazard (Canada)


12
1
9
7
3
5
8
2
6
11
10
4
5B
0
200
km

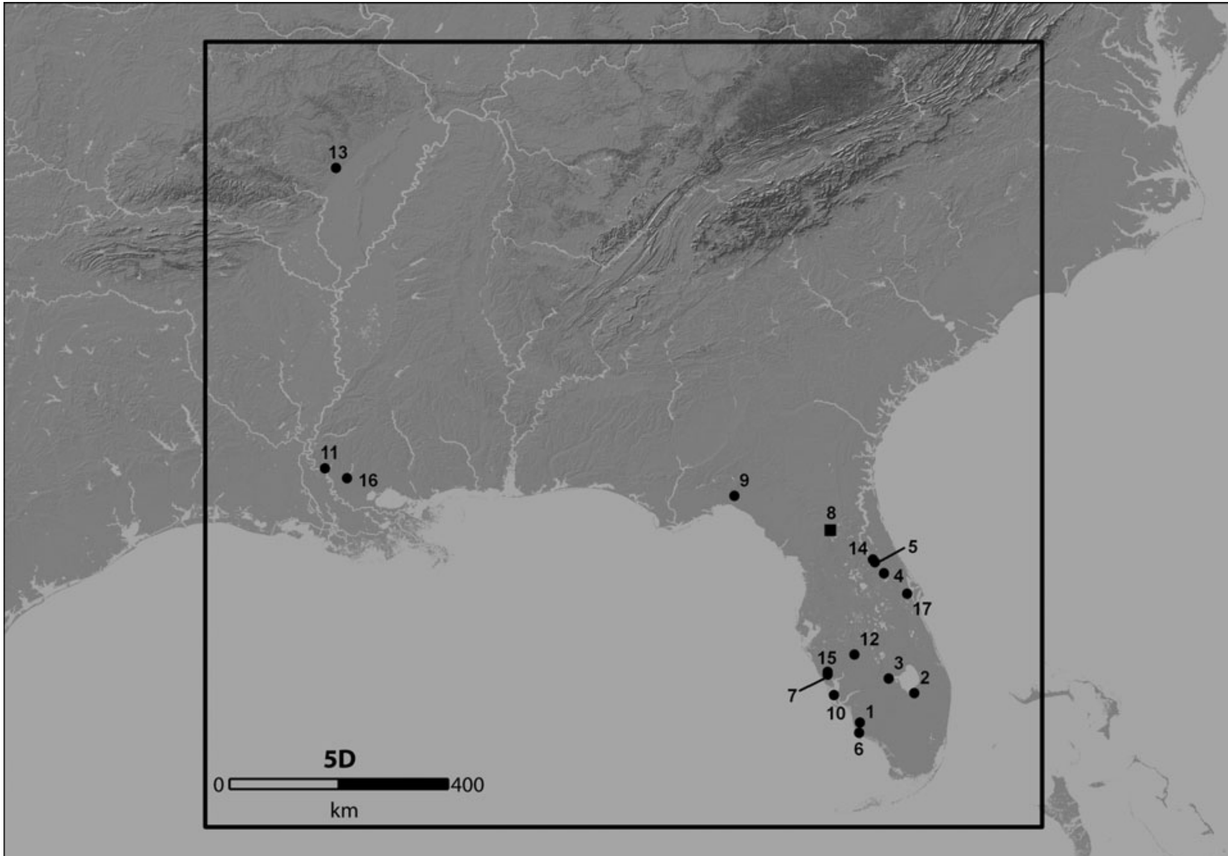
Map 5B
(Northwestern United States)

1) Ahnkuti (United States)
2) Danger Cave (United States)
3) Diamond Swamp (United States)
4) Hidden Cave (United States)
5) Lake Albert-Chewaucan Marsh (United States)
6) Lovelock (United States)
7) Malheur Lake (United States)
8) Nightfire Island (United States)
9) Osprey (United States)
10) Spirit Cave (United States)
11) Stillwater Marsh (United States)
12) Sunken Village (United States)


1
2
3
4
5C
0
400
km

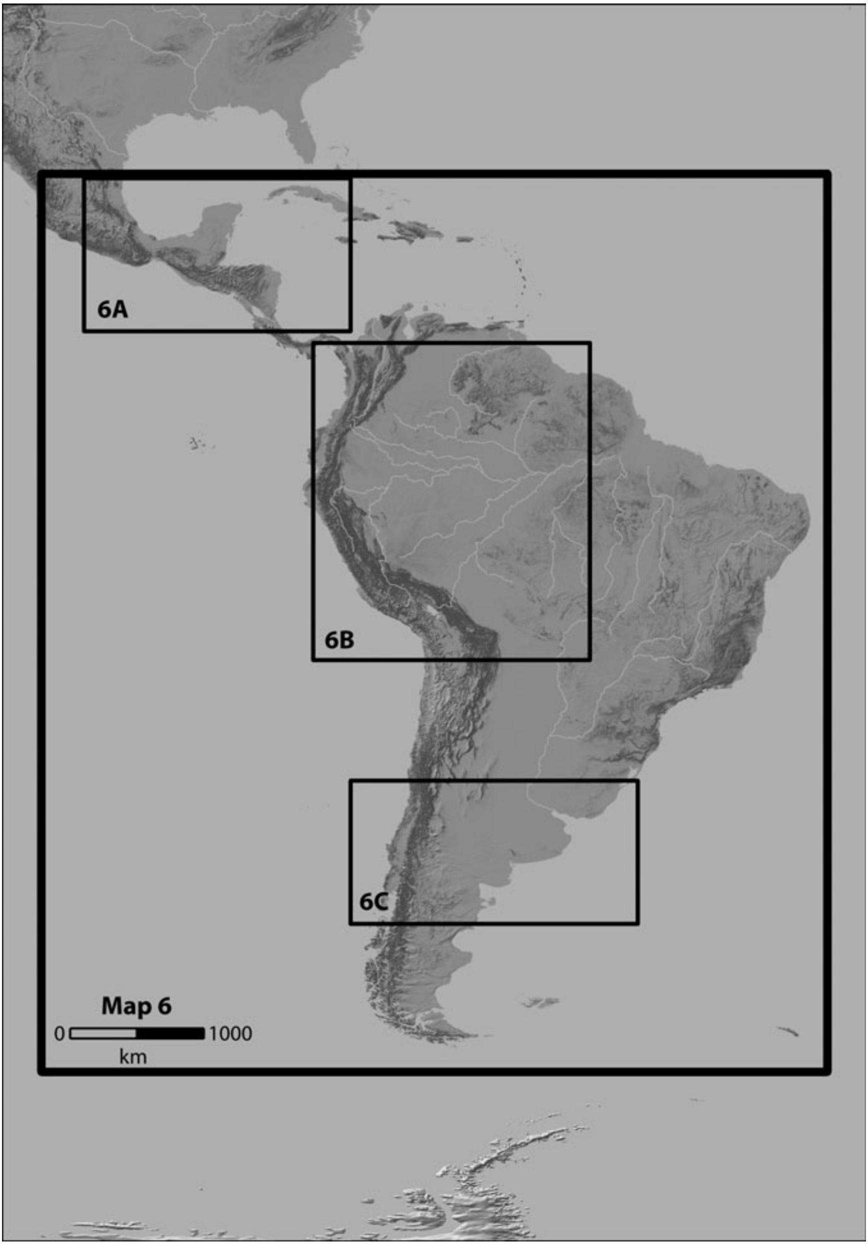
Map 5C
(Northeastern Canada; Northeastern United States)

1) Anse aux Meadows (Canada)
2) Atherley Narrows (Canada)
3) Back Bay (United States)
4) Robbins Swamp (United States)

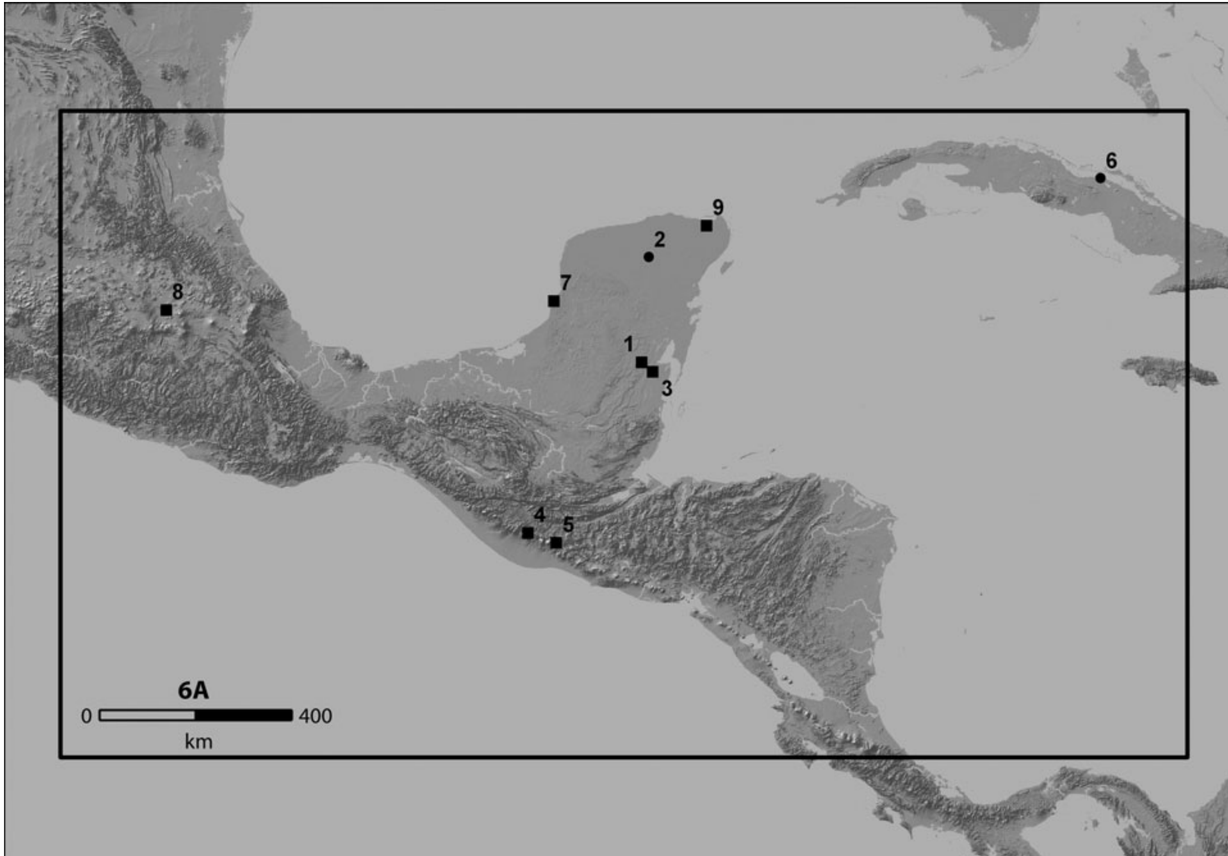

13
11
16
9
8
14
5
4
17
12
15
3
2
7
10
1
6
5D
0
400
km

Map 5D
(Southeastern United States)

1) Bay West (United States)
2) Belle Glade (United States)
3) Fort Center (United States)
4) Grove Orange Midden (United States)
5) Hontoon Island (United States)
6) Key Marco (United States)
7) Little Salt Spring (United States)
8) Newnans Lake (United States)
9) Page-Ladson (United States)
10) Pineland Site Complex (United States)
11) Poverty Point (United States)
12) Republic Groves (United States)
13) Sloan (United States)
14) Tick Island (United States)
15) Warm Mineral Springs (United States)
16) Watson Brake (United States)
17) Windover (United States)


6A
6B
6C
Map 6
0 1000
km

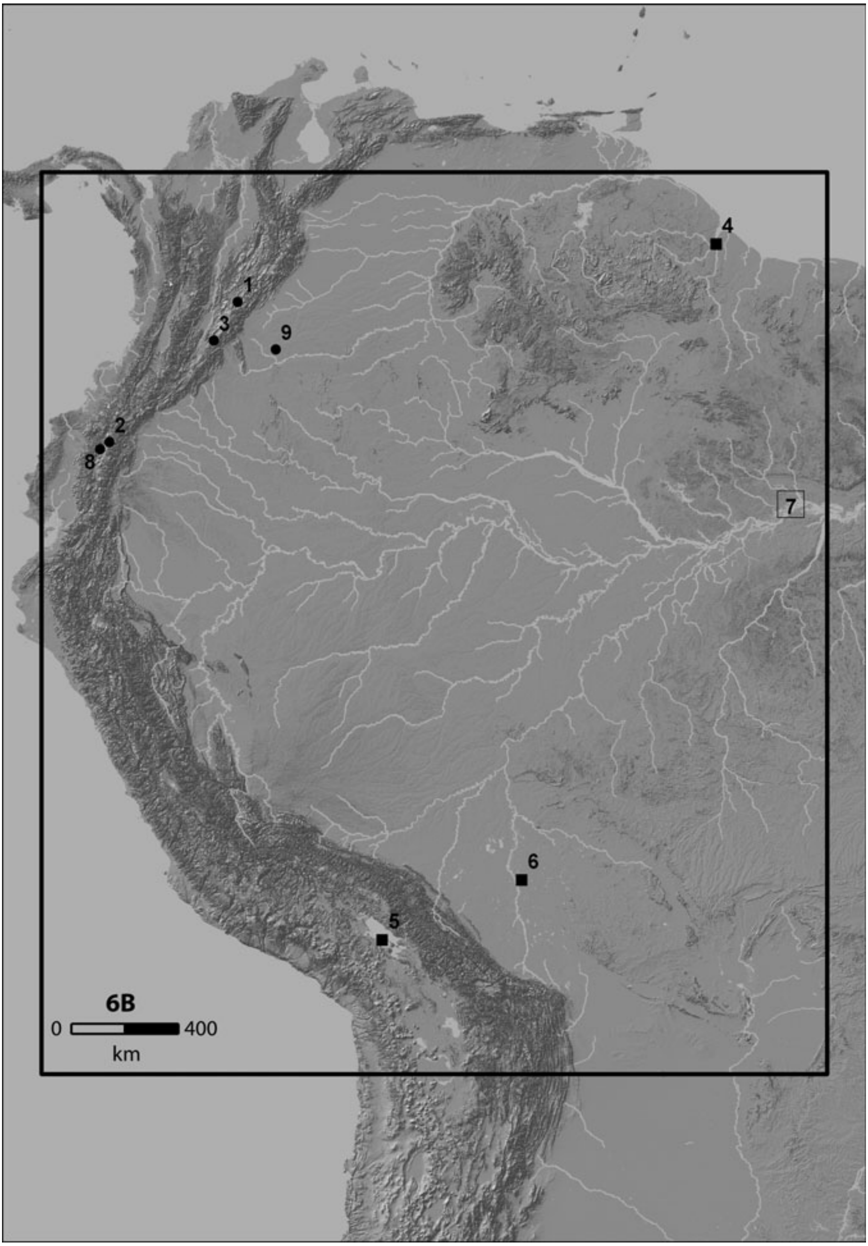
Map 6: Central and South America
Map 6A (Mesoamerica: Belize, Cuba, Guatemala, Mexico)
Map 6B (South America: Bolivia, Brazil, Colombia, Ecuador, Guyana, Peru)
Map 6C (South America: Chile, Uruguay)



6
9
2
7
8
1
3
4
5
6A
0
400
km

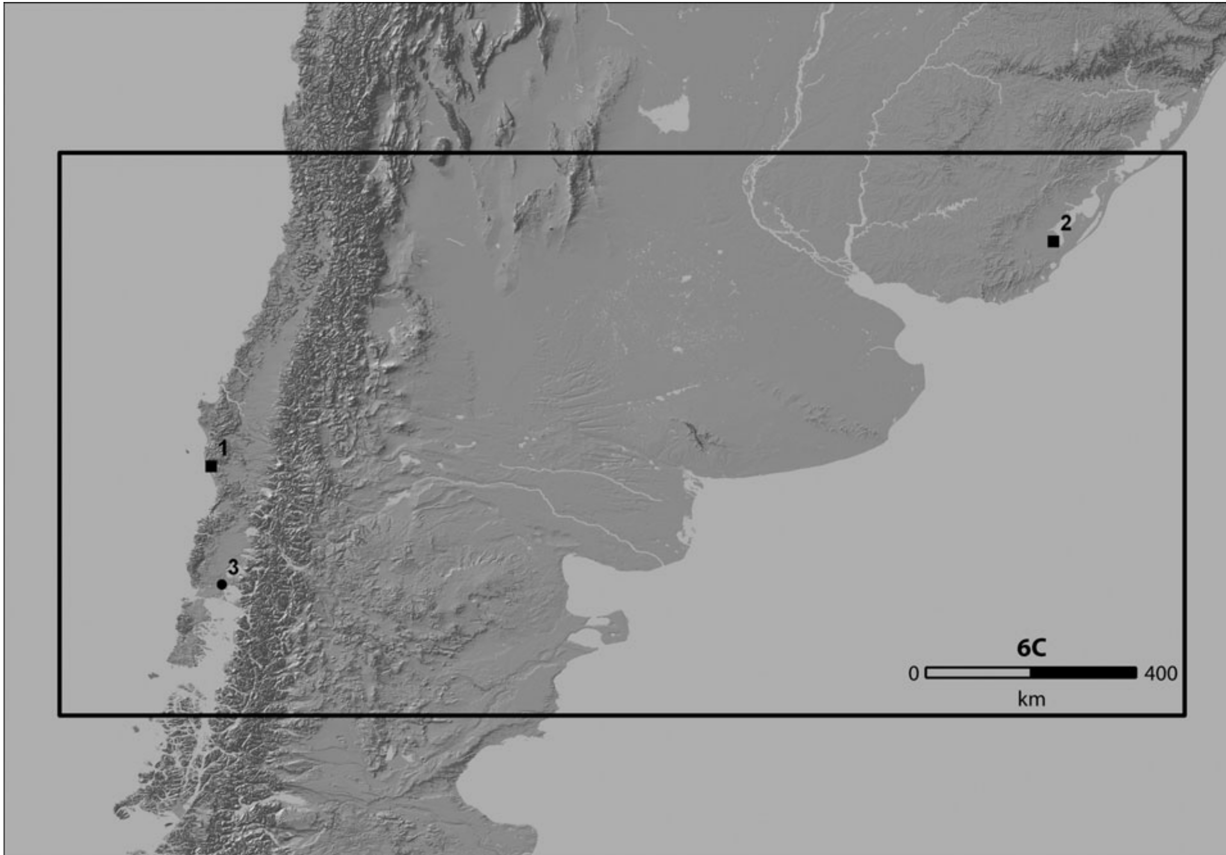
Map 6A
(Mesoamerica: Belize, Cuba, Guatemala, Mexico)

1) Bajo Marocoy (Mexico)
2) Chichén Itzá (Mexico)
3) Floodplain of the Rio Bravo (Belize)
4) Lake Atitlan (Guatemala)
5) Lake Miraflores (Guatemala)
6) Los Buchillones (Cuba)
7) Plain of Campeche (Mexico)
8) Valley of Mexico (Mexico)
9) Yalahan region (Mexico)


1
2
3
4
5
6
7
8
9
6B
0
400
km

Map 6B
(South America: Bolivia, Brazil, Colombia, Ecuador, Guyana, Peru)

1) Bogotá (Colombia)
2) Cayambe (Ecuador)
3) Colombia (Colombia)
4) Guianas Coastal Plain (Guyana)
5) Lake Titicaca (Peru)
6) Llanos de Mojos (Bolivia)
7) Middle Amazon Flood Plain (Brazil)
8) Quito (Ecuador)
9) San Jorge (Colombia)


1
2
3
6C
0
400
km

Map 6C
(South America: Chile, Uruguay)

1) Imperial River Delta (Chile)
2) Merin Lagoon (Uruguay)
3) Monte Verde (Chile)

References

Aalbersberg, G., and Brown, A. G. (2010) 'The environment and context of the Glastonbury Lake Village: A re-assessment'. *Journal of Wetland Archaeology* 10: 136–51.

Achermann, F. H. (1920) *Der Schatz des Pfahlbauers.* Olten: Walter.

Adams, C., Murrieta, R., Neves, W. and Harris, M. (eds.) (2008) *Amazon peasant societies in a changing environment: Political ecology, modernity and ecology in the rainforest.* New York: Springer.

Adams, R. and Nissen, H. (1972) *The Uruk countryside.* Chicago: University of Chicago Press.

Adams, R. E., Robichaux, H., Valdez, J., Houck, B., and Mathews, R. (2004) 'Transformations, periodicity, and urban development in the Three Rivers Region'. In A. Demarest, P. Rice, and D. Rice (eds.), *The Terminal Classical in the Maya Lowlands: Collapse, transition and transformation*. Boulder: University Press of Colorado, 302–23.

——Brown, E., and Culbert, T. P. (1981) 'Radar mapping, archaeology and ancient Mayan land use'. *Science* 213: 1457–63.

Adamus, P. R., and Brandt, K. (1990) *Impacts on quality of inland wetlands of the United States: A survey of indicators, techniques, and applications of community-level biomonitoring data.* Washington, DC: US Environmental Protection Agency.

Adkin, G. L. (1948) *Horowhenua: its Maori place-names & their topographic & historical background.* Wellington: Department of Internal Affairs.

Affolter, J. (2002) *Provenance des silex préhistoriques du Jura et des régions limitrophes.* Neuchâtel: Musée cantonal d'archéologie.

Akeret, Ö., and Rentzel, P. (2001) 'Micromorphology and plant macrofossil analysis of cattle dung from the Neolithic lake shore settlement of Arbon-Bleiche 3'. *Geoarchaeology* 16: 687–700.

Alavi, S. M. Z. (1965) *Arab geography in the ninth and tenth centuries.* Aligarh: Aligarh Muslim University.

Albarella, U. (1999) '"The mystery of husbandry": Medieval animals and the problem of integrating historical and archaeological evidence'. *Antiquity* 73: 867–75.

Albore Livadie, C., Bartoli, C., Boenzi, G., Cicirelli, C., and Guzzo, P. G. (2005) 'The Poggiomarino River settlement in the Longola area'. In Proceedings of the 6th Conference of Italian Archaeology (ed.), *Papers in Italian Archaeology: Communities and settlements from the Neolithic to the Early Medieval period.* BAR International Series 1452. Oxford: Archaeopress, 699–705.

Alfaro, C., and Karali, L. (eds.) (2008) *Purpureae vestes II: vestidos, textiles y tintes: estudios sobre la producción de bienes de consumo en la antigüedad.* Valencia: University of Valencia.

Allaby, T. G., Peterson, G. W., Merriwether, D. A., and Fu, Y.-B. (2005) 'Evidence of the domestication history of flax (*Linum usitatissimum L.*) from genetic diversity of the sad2 locus'. *Theoretical and Applied Genetics* 112 (1): 58–65.

Allen, M. J., and Gardiner, J. (2000) *Our changing coast: A survey of the intertidal archaeology of Langstone Harbour, Hampshire. Council for British Archaeological Research Report 124.* York: Council for British Archaeology.

Allen, T. G., and Robinson, M. A. (1993) *The prehistoric landscape and Iron Age enclosed settlement at Mingies Ditch, Hardwich-with-Yelford, Oxon.* London: Council for British Archaeology.

Almkvist, G., and Persson, I. (2009) 'Iron catalysed degradation processes in the Vasa'. In K. Straetkvern and D. J. Huisman (eds.), *Proceedings of the 10th ICOM Group on Wet Organic Archaeological Materials Conference, Amsterdam 2007.* Amersfoort: ICOM Committee for Conservation Working Group on Wet Organic Archaeological Materials, 499–506.

Altorfer, K. (2010) *Die prähistorische Feuchtbodensiedlungen am Südrand des Pfäffikersees. Eine archäologische Bestandesaufnahme der Stationen Wetzikon-Robenhausen und Wetzikon-Himmerich.* Monografien der Kantonsarchäologie Zürich 41. Zurich: FO Print & Media.

——Huber, R., and Médard, F. (2001) 'Taucher, Thesen und Textilien. Neue Untersuchungen zum jungneolithischen Textilhandwerk in den Feuchtbodensiedlungen von Wetzikon-Robenhausen (Kanton Zürich)'. *Plattform* 9–10: 78–93.

——(2004*a*) 'Pfahlbautourismus und Pfahlbauentdeckungen im Ausland'. In Antiquarische Gesellschaft in Zürich (ed.), *Pfahlbaufieber: Von Antiquaren, Pfahlbaufischern, Altertümerhändlern und Pfahlbaumythen*. Zurich: Chronos, 91–101.

——(2004*b*) 'Von Pfahlbaufischern und Alterthümerhändlern'. In Antiquarische Gesellschaft in Zürich (ed.), *Pfahlbaufieber: Von Antiquaren, Pfahlbaufischern, Altertümerhändlern und Pfahlbaumythen*: Zurich: Chronos, 103–24.

Ames, K. M., and Maschner, H. D. G. (1999) *Peoples of the Northwest Coast, their archaeology and prehistory.* London: Thames & Hudson.

Ammerman, A. J., and Cavalli-Sforza, L. L. (1971) 'Measuring the rate of spread of early farming in Europe'. *Man* 6: 674–88.

——(1984) *The Neolithic transition and the genetics of population in Europe.* Princeton, NJ: Princeton University Press.

Andersen, S. H. (1985) 'Tybrind Vig: A preliminary report on a submerged Ertebølle settlement on the West Coast of Fyn'. *Journal of Danish Archaeology* 4: 52–70.

——(1994) 'New finds of Mesolithic logboats in Denmark'. In C. Westerdahl (ed.), *Crossroads in ancient shipbuilding*. Oxford: Oxbow, 1–10.

——(2011) 'Ertebølle Canoes and Paddles from the Submerged Habitation Site of Tybrind Vig, Denmark'. In J. Benjamin, C. Bonsall, C. Pickard, and A. Fischer (eds.), *Submerged Prehistory*. Oxford: Oxbow, 1–14.

Andersen, S. T. (1995) 'History of vegetation and agriculture at Hassing Huse Mose, Thy, North-Western Denmark, Since the Ice Age'. *Journal of Danish Archaeology* 11: 57–79.

Anderson, A. J. (1991) 'The chronology of colonization in New Zealand'. *Antiquity* 65: 767–95.

Andersson, E. (2007) 'Engendering central places: some aspects of the organisation of textile production during the Viking Age'. In A. Rast-Eicher and R. Windler (eds.), *Archäologische Textilfunde Archaeological Textiles NESAT IX*. Ennenda: ArcheoTex, 148–53.

——Mårtensson, M.-L., Rahmstorf, N., and Rahmstorf, L. (2008) 'New research on Bronze Age textile production'. *Bulletin of the Institute of Classical Studies* 51: 171–4.

Apals, J. (1965) 'Klāstu mītnes Latvijas psr teritorijā'. *Latvijas psr zinātnu akadēmijas vēstis* 5: 45–62.

——(1993) *Die Wohninsel Araisi.* Cesis: Museen-Assoziation Cesis.

Arbogast, R.-M., Jacomet, S., Magny, M., and Schibler, J. (2006) 'The significance of climate fluctuations for lake level changes and shifts in Ssubsistence economy during the Late Neolithic (4300–2400 bc) in Central Europe'. *Vegetation History and Archaeobotany* 15: 403–18.

——Jeunesse, C., and Schibler, J. (eds.) (2001) *Rolle und Bedeutung der Jagd während des Frühneolithikums Mitteleuropas (Linearbandkeramik 5500–4900 v. Chr.).* Rahden: Marie Leidorf.

Armstrong, K. (2010) 'Archaeological geophysical prospection in peatland environments'. Unpublished PhD. thesis. Bournemouth University.

Arnaud, F., Revel, M., Chapron, E., Desmet, M., and Tribovillard, N. (2005) '7200 Years of Rhône river flooding activity in Lake Le Bourget, France: A high-resolution sediment record of NW Alps hydrology'. *The Holocene* 15: 420–8.

Arnold, B. (1983) 'Les 24 Maisons d'Auvernier-Nord (Bronze Final)'. *Jahrbuch der schweizerischen Gesellschaft für Ur- und Frühgeschichte* 66: 87–104.

——(1996) *Pirogues monoxyles d'Europe centrale: construction, typologie, évolution.* Neuchâtel: Musée cantonal d'archéologie.

——(1999) 'Archaeology on the shores of Lake Neuchâtel. Past and present'. In B. J. Coles, J. M. Coles, and M. S. Jørgensen (eds.), *Bog Bodies, Sacred Sites and Wetland Archaeology*. Exeter: Wetland Archaeology Research Project, 11–16.

——(2004) 'Dover to Bevaix, from the Middle Bronze Age to Gallo-Roman times, from lashing to nailing: A page of naval archaeology illustrated by the evolution of techniques, tools and the discovery of new materials'. In P. Clark (ed.), *The Dover Bronze Age boat in context: Society and water transport in prehistoric Europe*. Oxford: Oxbow, 82–9.

——(2009) 'Altaripa, ein Forschungsprojekt zur Ursprung des keltischen Schiffsbaus'. *Dossiers D'Archéologie* 333: 74–9.

——Hafner, A., Wolf, M. M., Mauvilly, M., Winiger, A., and Wolf, C. (2004) 'Die Region der drei Seen—im Grenzraum zwischen Romandie und Deutschschweiz'. *Archäologie Schweiz* 27 (2): 42–53.

Arnoldussen, S. (2008*a*) *A living landscape: Bronze Age settlement sites in the Dutch river area (c.2000–800 bc).* Leiden: Sidestone.

——(2008*b*) *A living landscape: Bronze Age settlements in the Dutch river area (2000–800 bc).* Leiden: Faculty of Archaeology, Leiden University.

——and Fokkens, H. (2008) 'Bronze Age settlement sites in the Low Countries: An overview'. In S. Arnoldussen and H. Fokkens (eds.), *Bronze Age settlements in the Low Countries.* Oxford: Oxbow, 17–40.

Arnott, S. H. L., Dix, J. K., Best, A. I., and Gregory, D. J. (2005) 'Imaging of buried archaeological materials: The reflection of archaeological wood'. *Marine Geophysical Researches* 26: 135–44.

Ashmore, P. J. (1996) *Neolithic and Bronze Age Scotland*. London: Batsford.

Asingh, P., and Lynnerup, N. (eds.) (2007) *Grauballe Man.An Iron Age bog body revisited.* Højbjerg: Moesgaard Museum and Jutland Archaeological Society.

Babiński, L., Fejfer, M., and Prądzyński, W. (2007) 'Environmental monitoring at the Lusatian culture settlement in Biskupin, Poland'. *Journal of Wetland Archaeology* 7: 51–72.

Bagniewski, Z. (1998) 'Later Mesolithic Settlement in Central and Eastern Pomerania'. In M. Zvelebil, L. Domańska, and R. Dennell (eds.), *Harvesting the sea, farming the forest: The emergence of Neolithic societies in the Baltic Region* Sheffield: Sheffield Academic Press, 111–19.

Bailey, G. (2007) 'The Palaeogeography of the North Sea Basin'. In C. Waddington and K. Pedersen (eds.), *Mesolithic studies in the North Sea Basin and beyond: Proceedings of a conference held at Newcastle in 2003*. Oxford: Oxbow, 3–11.

Baillie, M. G. L. (1982) *Tree-ring dating and archaeology*. London: Croom Helm.

——(1995) *A Slice through time: Dendrochronology and precision dating*. London: Routledge.

Bakels, C. (2001) 'Producers and consumers in archaeobotany. A comment on "When method meets theory: The use and misuse of cereal producer/consumer models in archaeobotany"'. In U. Albarella (ed.), *Environmental Archaeology: Meaning and Purpose*. Dordrecht: Kluwer Academic, 299–304.

Baker, C., Thompson, J. R., and Simpson, M. (2009) 'Hydrological dynamics I: Surface waters, flood and sediment dynamics'. In E. Maltby and T. Barker (eds.), *The wetlands handbook* Oxford: Blackwell, 120–68.

Balaam, N. D., Bell, M., David, E., Levitan, B., McPhail, R. I., Robinson, M. A., and Scaife, R. G. (1987) 'Prehistoric and Romano-British sites at Westward Ho!, Devon: Archaeological and palaeoenvironmental surveys 1983 and 1984'. In N. D. Balaam, B. Levitan, and V. Straker (eds.), *Studies in palaeoeconomy and environment in South West England*. British Archaeological Reports 181. Oxford: Archaeopress, 163–264.

——Smith, K., and Wainwright, G. J. (1982) 'The Shaugh Moor Project—the Fourth Report'. *Proceedings of the Prehistoric Society* 48: 203–78.

Balée, W., and Erickson, C. L. (eds.) (2006) *Time and complexity in historical ecology*. New York: Columbia University Press.

Ballin, T. B. (2007) 'The territorial structure in the Stone Age of Southern Norway: A comparative analysis of selected Lithic assemblages from Southern Norway, Western Sweden and Southern Scandinavia'. In C. Waddington and K. Pedersen (eds.), *Mesolithic studies in the North Sea Basin and beyond: Proceedings of a conference held at Newcastle in 2003*. Oxford: Oxbow, 114–30.

Balme, J. (1995) '30,000 years of fishery in western New South Wales'. *Archaeology in Oceania* 30 (1): 1–21.

Bánffy, E. (2000) 'The Late Starčevo and the earliest Linear Pottery groups in western Transdanubia'. *Documenta Praehistorica* 27: 173–86.

Barham, L. S., and Mitchell, P. J. (2008) *The first Africans: African archaeology from the earliest toolmakers to most recent foragers*. Cambridge: Cambridge University Press.

Barker, G. (1985) *Prehistoric farming in Europe*. Cambridge: Cambridge University Press.

——(2006) *The agriculture revolution in prehistory: Why did foragers become farmers?* Oxford: Oxford University Press.

Barnes, G. L. (1993) *China, Korea and Japan: The rise of civilisation in East Asia.* London: Thames & Hudson.

Bauer, I., and Leuzinger, U. (2004) 'Experiment Pfahlbauarchäologie'. *Archäologie Schweiz* 27 (2): 73–7.

Bauerochse, A. (2001) 'Ergebnisse erster Bodenradaruntersuchungen aus dem Campemoor'. *Berichte zur Denkmalpflege in Niedersachsen* 21 (2): 48–50.

——(2003) 'Environmental change and its influence on trackway construction and settlement in the south-western Dümmer area'. In A. Bauerochse and H. Haßmann (eds.), *Peatlands: Archaeological sites—archives of nature—nature conservation—wise use*. Rahden: Marie Leidorf, 68–78.

Bauerochse, A., Haßmann, H., and Püschel, K. (eds.) (2008) *'Moora'—Das Mädchen aus dem Uchter Moor. Eine Moorleiche der Eisenzeit aus Niedersachsen I*. Rahden: Marie Leidorf.

Bauerochse, A., and Metzler, A. (2003) 'Archäologie'. In Naturschutz und Informationszentrum Niedersächsisches Landesamt für Denkmalpflege and Museum im Zeughaus (ed.), *Moor Zeiten: 3x Moor im Oldenburger Münsterland*. Diepholz: Schröderscher Buchverlag, 45–92.

Bayliss-Smith, T. P. (1988) 'Prehistoric agriculture in the New Guinea Highland: Problems in defining the altitudinal limits to growth'. In J. Bintliff and D. Davidson (eds.), *Conceptual issues in environmental archaeology*. Edinburgh: Edinburgh University Press, 153–60.

——(1996) 'People–plant interactions in the New Guinea highlands: Agricultural heartland or horticultural backwater?' In D. R. Harris (ed.), *The origins and spread of agriculture and pastoralism in Eurasia*. London: UCL, 499–523.

——(2007) 'The meaning of ditches: Interpreting the archaeological record from New Guinea using insights from ethnography'. In T. P. Denham, J. Iriarte, and L. Vrydaghs (eds.), *Rethinking agriculture: Archaeological and ethnoarchaeological perspectives*. Walnut Creek, Calif.: Left Coast, 126–48.

——and Golson, J. (1992*a*) 'A Colocasian revolution in the New Guinea Highlands? Insights from Phase 4 at Kuk'. *Archaeology in Oceania* 27 (1): 1–21.

——(1992*b*) 'Wetland agriculture in New Guinea Highlands prehistory'. In B. J. Coles (ed.), *The Wetland revolution in prehistory*. Exeter: Prehistoric Society, 15–27.

Bazzanella, M., Mayr, A., Moser, L., and Rast-Eicher, A. (eds.) (2003) *Textiles. Intrecci e tessuti dalla preistoria europea.* Riva del Garda, Trento: Provincia Autonoma di Trento.

Beach, T., Luzzadder-Beach, S., Dunning, N., Jones, J., Lohse, J., Guderjan, T., Bozarth, S., Millspaugh, S., and Bhattacharya, T. (2009) 'A review of human and natural changes in Maya Lowlands Wetlands over the Holocene'. *Quaternary Science Reviews* 28: 1710–24.

Bech, J.-H. (1993) 'Settlements on the raised sea-bed at Bjerre, northern Thy'. In S. Hvass, B. Storgaard, and U. L. Hansen (eds.), *Digging into the past: 25 years of archaeology in Denmark*. Copenhagen: Åarhus University Press, 142–3.

——(1997) 'Bronze Age settlements on raised sea-beds at Bjerre, Thy, NW-Jutland'. In J. J. Assendorp (ed.), *Forschungen zur bronzezeitlichen Besiedlung in Nord- und Mitteleuropa*. Espelkamp: Institut für Denkmalpflege im Niedersächsischen Landesverwaltungsamt, 3–15.

——(2003) 'The Thy Archaeological Project—results and reflections from a multinational archaeological project'. In H. Thrane (ed.), *Diachronic settlement studies in the Metal Ages*. Højbjerg: Jutland Archaeological Society, 45–60.

Becker, B. (1985) 'Die absolute Chronologie der Pfahlbauten nördlich der Alpen im Jahrringkalender Mitteleuropas'. In B. Becker, A. Billamboz, H. Egger, P. Gassmann, C. Orcel, and U. Ruoff (eds.), *Dendrochronologie in der Ur- und Frühgeschichte: Die absolute Datierung von Pfahlbausiedlungen nördlich der Alpen im Jahrringkalender Mitteleuropas.* Basel: Schweizerische Gesellschaft für Ur- und Frühgeschichte, 8–28.

——(1993) 'An 11,000-year German oak and pine dendrochronology for radiocarbon calibration'. *Radiocarbon* 35: 210–13.

Beer, H., and Schmid, W. (1997) 'Pfahlbauten im Starnberger See'. In H. Schlichtherle (ed.), *Pfahlbauten rund um die Alpen*. Stuttgart: Konrad Theiss, 88–90.

Bell, M. (1993) 'Field survey and excavation at Goldcliff, Gwent 1993'. *Archaeology in the Severn Estuary* 4: 81–102.

——(1999) 'Prehistoric settlements and activities in the Welsh Severn Estuary'. In B. J. Coles, J. M. Coles, and M. S. Jørgensen (eds.), *Bog Bodies, Sacred Sites and Wetland Archaeology*. Exeter: Wetland Archaeology Research Project, 17–25.

——(2001) 'Environmental archaeology in the Severn Estuary: progress and prospects'. In S. Rippon (ed.), *Estuarine archaeology: The Severnand beyond*. Exeter: Severn Estuary Levels Research Committee, 69–103.

——(2007) *Prehistoric coastal communities: The Mesolithic in western Britain*. York: Council for British Archaeology.

——Caseldine, A., and Neumann, H. (2000) *Prehistoric intertidal archaeology in the Welsh Severn Estuary.* York: Council of British Archaeology.

——Fowler, P. J., and Hillson, S. W. (eds.) (1996) *The Experimental Earthwork Project, 1960–1992.* York: Council for British Archaeology.

——Chisham, C., Dark, P., and Allen, S. (2006) 'Mesolithic sites in coastal and riverine contexts in southern Britain: Current research and the management of the archaeological resource'. In E. Rensink and H. Peeters (eds.), *Preserving the early past: Investigation, selection and preservation of Palaeolithic and Mesolithic sites and landscapes*. Amersfoort: National Service for Archaeological Heritage, 25–39.

Bellintani, P., and Stefan, L. (2009) 'Nuovi dati sul primo vetro europeo: il caso di Frattesina'. In Convegno Interdisciplinare (ed.), *Proceedings of Primo Convegno Interdisciplinare sul Vetro nei Beni Culturali e nell'Arte di Ieri e di Oggi*. Parma: Convegno Interdisciplinare, 71–86.

Bellwood, P. S. (1978) *Archaeological research at LakeMangakaware, Waikato, 1968–1970.* Dunedin: New Zealand Archaeological Association.

——(1996) 'The origins and spread of agriculture in the Indo-Pacific region: Gradualism and diffusion or revolution and colonization?' In D. R. Harris (ed.), *The origins and spread of agriculture and pastoralism in Eurasia*. London: UCL, 465–98.

——(1997) *Prehistory of the Indo-Malaysian Archipelago.* Honolulu: University of Hawaii Press.

——(2005) *First farmers: The origins of agricultural societies.* Oxford: Blackwell.

——and Renfrew, C. (eds.) (2002) *Examining the farming/language dispersal hypothesis.* Cambridge: McDonald Institute for Archaeology.

Benson, L. V., Hattori, E. M., Taylor, H. E., Poulson, S. R., and Jolie, E. A. (2006) 'Isotope sourcing of prehistoric willow and tule textiles recovered from western Great Basin rock shelters and caves—proof of concept'. *Journal of Archaeological Science* 33 (11): 1588–99.

Berglund, B., Birks, H. J. B., Ralska-Jasiewczowa, M., and Wright, H. E. J. (1986) *Palaeoecological events during the last 15,000 years.* Chichester: John Wiley & Son.

Beriault, J., Carr, R., Stipp, J., Johnson, R., and Meeder, J. (1981) 'The archaeological salvage of the Bay West site, Collier County, Florida'. *The Florida Anthropologist* 34: 39–58.

Bernabó Brea, M., and Cremaschi, M. (1997) 'La terramare di S. Rosa di Poviglio: le strutture'. In M. Bernabó Brea, A. Cardarelli, and M. Cremaschi (eds.), *Le terramare: La più antica civiltà padana*. Milan: Electa, 196–249.

——Cardarelli, A., and Cremaschi, M. (1997) 'Terramare. Cinque secoli di vita nella grande pianura'. In M. Bernabó Brea, A. Cardarelli, and M. Cremaschi (eds.), *Le terramare: La più antica civiltà padana*. Milan: Electa, 23–9.

Bernicchia, A., Fugazzola Delpino, M. A., Gemelli, V., Mantovani, B., Lucchetti, A., Cesari, M., and E., S. (2006) 'DNA recovered and sequenced from an almost 7000 y-old Neolithic polypore, Daedaleopsis tricolor'. *Mycological Research* 110: 14–17.

Bernick, K. (1983) *A site catchment analysis of the Little Qualicum River Site, DiSc 1: A wet site on the East Coast of Vancouver Island, BC.* Ottawa: National Museums of Canada.

——(1998) 'Stylistic characteristics of basketry from Coast Salish Area wet sites'. In K. Bernick (ed.), *Hidden dimensions: The cultural significance of wetland archaeology*. Vancouver: University of British Columbia Press, 139–56.

——(2001) 'Serendipitous discoveries: The Water Hazard Wet Site in Southwestern British Columbia'. In B. A. Purdy (ed.), *Enduring records: The environmental and cultural heritage of wetlands*. Oxford: Oxbow, 110–19.

——(2007) 'Identifying anthropogenic deposits in alluvial deposits on the Northwest Coast'. In J. W. Barber, C. Clark, M. Cressey, A. Crone, A. Hale, J. C. Henderson, R. A. Housley, R. Sands, and A. Sheridan (eds.), *Archaeology from the wetlands: Recent perspectives*. Edinburgh: Society of Antiquaries of Scotland, 127–33.

Bertone, A., and Fozzati, L. (eds.) (2004) *La civiltá di Viverone.* Biella: Eventi & Progetti.

——(2006) 'Les palafittes de Viverone et le Bronze moyen de l'Italie nord-occidentale'. In A. Hafner, U. Niffeler, and U. Ruoff (eds.), *Die neue Sicht—Unterwasserarchäologie und Geschichtsbild.* Basel: Archäologie Schweiz, 75–8.

Besteman, J. C. (1990) 'North Holland AD 400–200: Turning tide or tide turned?' In J. C. Besteman, J. M. Bos, and H. A. Heidinga (eds.), *Medieval archaeology in the Netherlands. Studies presented to H. H. van Regteren Altena.* Assen: Van Gorcum, 91–120.

Betts, R. C. (1998) 'The Montana Creek Fish Trap I: Archaeological investigations in Southeast Alaska'. In K. Bernick (ed.), *Hidden dimensions: The cultural significance of wetland archaeology*. Vancouver: University of British Columbia Press, 239–51.

Billamboz, A. (1997) 'Das Holz der Pfahlbausiedlungen'. In H. Schlichtherle (ed.), *Pfahlbauten rund um die Alpen*. Stuttgart: Konrad Theiss, 108–14.

——(1998) 'Zur dendrochronologischen Datierung der Bohlenwege an der Wuhrstrasse westlich von Bad Buchau, Kreis Biberach'. *Archäologische Ausgrabungen in Baden-Württemberg* 1997: 50–2.

——(2003) 'Tree rings and wetland occupation in southwest Germany between 2000 and 500 BC: Dendroarchaeology beyond dating'. *Tree-Ring Research* 59: 37–49.

——(2004) 'Dendrochronology in lake-dwelling research'. In F. Menotti (ed.), *Living on the lake in prehistoric Europe: 150 years of lake-dwelling research*. London: Routledge, 117–31.

——(2005) '20 Jahre Dendroarchäologie in den Pfahlbausiedlungen Südwestdeutschlands. Bilanz und Perspektiven'. In P. Della Casa and M. Trachsel (eds.), *WES'04: Wetland economies and societies*. Zurich: Chronos, 47–56.

——(2006) 'Dendroarchäologische Untersuchungen in den neolitische Ufersiedlungen von Hornstaad-Hörnle'. In Landesamt für Denkmalpflege (ed.), *Siedlungsarchäologie im Alpenvorland IX*. Stuttgart: Konrad Theiss, 297–414.

——(2010) 'Dendroarchéologie sur le bord du lac de Constance: de la forêt au village, que de bois devant la maison palafittique'. In I. Matuschik, C. Strahm, B. Eberschweiler, G. Fingerlin, A. Hafner, M. Kinsky, M. Mainberger, and G. Schöbel (eds.), *Vernetzungen: Aspekte siedlungsarchäologischer Forschung (Festschrift für Helmut Schlichtherle)*. Freiburg: Lavori, 81–94.

——and Köninger, J. (2008) 'Dendroarchäologische Untersuchungen zur Besiedlungs- und Landschaftsentwicklung im Neolithikum des westlichen Bodenseegebietes'. In W. Dörfler and J. Müller (eds.), *Umwelt—Wirtschaft—Siedlungen im dritten vorchristlichen Jahrtausend Mitteleuropas und Südskandinaviens*. Neumünster: Wachholz, 317–34.

Bilz, M., Dean, L., Grattan, D. W., McCawley, J. C., McMillen, L., and Cook, C. (1994) 'A study of the thermal breakdown of polyethylene glycol'. In P. Hoffman, T. Daley, and T. Grant (eds.), *Proceedings of the 5th ICOM Group on Wet Organic Archaeological Materials Conference Portland/Maine 1993*. Portland, Me.: ICOM Committee for Conservation Working Group on Wet Organic Archaeological Materials, 167–97.

Binford, L. R. (1981) 'Behavioral archaeology and the Pompeii premise'. *Journal of Anthropological Research* 37: 195–208.

——(1983) *In pursuit of the past: Decoding the archaeological record.* New York: Thames & Hudson.

Bird, C., and Frankel, D. (1991) 'Chronology and explanation in western Victoria and southeast Australia'. *Archaeology in Oceania* 26 (1): 1–16.

Bjork, S. (1995) 'A review of the history of the Baltic Sea 13.0-8.0 thousand BP'. *Quaternary International* 27: 19–40.

Bleicher, N. (2009) *Altes Holz in neuem Licht. Archäologische und dendrochronologische Untersuchungen an spätneolithischen Feuchtbodensiedlungen Oberschwabens.* Stuttgart: Landesamt für Bodendenkmalpflege.

Bleuer, E., Hochuli, S., Nielsen, E., and Spycher, H. (2004) 'Die neolithischen und bronzezeitlichen Seeufersiedlungen des zentralen Mittellandes'. *Archäologie Schweiz* 27 (2): 30–41.

Boas, F. (1896) 'The limitations of the comparative method of anthropology'. *Science* 4: 901–8.

Boas, F. (1963 [1911]) *The mind of primitive man*. New York: Greenwood.

Bocquet, A. (1990) 'Le village néolitique des Baigneurs à Charavines Lac de Paladru (Isère)'. In Schweizerisches Landmuseum (ed.), *Die ersten Bauern*. Zurich: Schweizerisches Landesmuseum, 205–10.

——and Huot, A. (1994) *Charavines il y a 5000 ans*. Dijon: Editions Faton.

——Brochier, J. L., Emery-Barbier, A., Lundstrom-Baudais, K., Orcel, C., and Vin, F. (1987) 'A submerged Neolithic village: Charavines 'Les Baigneurs' in Lake Paladru, France'. In J. M. Coles and A. Lawson (eds.), *European wetlands in Prehistory*. Oxford: Clarendon, 33–54.

Bogaard, A. (2004) *Neolithic farming in Central Europe. An archaeobotanical study of crop husbandry practices*. London: Routledge.

Bogucki, P. (1979) 'Tactical and strategic settlements in the Early Neolithic of Lowland Poland'. *Journal of Anthropological Research* 35 (2): 238–46.

Boisaubert, J.-L., Bugnon, D., and Mauvilly, M. (2008) *Archaéologie et autoroute A1, destins croisés: 25 années de fouilles en terres fribourgeoises. Prepier bilan (1975–2000)*. Fribourg: Academic Press.

Bond, C. J. (2004) 'The Sweet Track, Somerset: A place mediating culture and spirituality?' In T. Insoll (ed.), *Belief in the Past. The Proceedings of the Manchester Conference on Archaeology and Religion*. Oxford: Archaeopress, 37–50.

——(2009) 'A Mesolithic social landscape in south-west Britain: the Somerset Levels and Mendip Hills'. In S. B. McCartan, R. Schulting, G. Warren, and P. Woodman (eds.), *Mesolithic horizons*. Oxford: Oxbow, 706–16.

Bonsall, C., Sutherland, D. G., Tipping, R. M., and Cherry, J. (1989) 'The Eskmeals project: Late Mesolithic settlement and environment in north-west England'. In C. Bonsall (ed.), *The Mesolithic in Europe*. Edinburgh: John Donald, 175–205.

Bonzon, J. (2004) 'Archaeometrical study (petrography, mineralogy and chemistry) of the ceramics'. In S. Jacomet, U. Leuzinger, and J. Schibler (eds.), *Die jungsteinzeitliche Seeufersiedlung Arbon-Bleiche 3*. Frauenfeld: Veröffentlichung des Amtes für Archäologie des Kantons Thurgau, 294–312.

Borić, D. (2003) '"Deep time" metaphor: Mnemoic and apotropaic practices at Lepenski Vir'. *Journal of Social Archaeology* 3 (1): 41–75.

——(2007) 'The house between grand narrative and microhistory: A house society in the Balkans'. In R. A. Beck (ed.), *The durable house: House society models in archaeology*. Carbondale, Ill.: Center for Archaeological Investigations, 97–129.

——(2008) 'First households and "house societies" in European Prehistory'. In A. Jones (ed.), *Prehistoric Europe: Theory and practice*. Oxford: Wiley-Blackwell, 109–42.

——(2010) 'Introduction: Memory, archaeology and historical condition'. In D. Borić (ed.), *Archaeology and memory*. Oxford: Oxbow, 35–47.

Bosch, A., Chinchilla, J., and Tarr'ys, J. (eds.) (2000) *El poblat lacustre neolític de La Draga: excavacions 1990-1998*. Girona: Museu d'Archeologia de Catalunya.

——(eds.) (2006) *Els objectes de fusta delpoblat neolític de La Draga: excavacións 1995–2005*. Girona: Museu d'Archeologia de Catalunya.

Bouchet, F., Harter, S., and Le Bailly, M. (2003) 'The state of the art of paleoparasitological research in the Old World'. *Memorias do Instituto Oswaldo Cruz* 98 (I): 95–101.

BOWLER, J. M., JOHNSTON, H., OLLEY, J., PRESCOTT, J., ROBERTS, R., SHAWCROSS, W., and SPOONER, N. (2003) 'New ages for human occupation and climatic change at Lake Mungo, Australia'. *Nature* 421: 837–9.

BRADLEY, J. (1991) 'Excavations at Moynagh Lough, Co. Meath'. *Journal of the Royal Society of Antiquaries of Ireland* 111: 5–26.

BRADLEY, R. (1990) *The passage of arms. An archaeological analysis of prehistoric hoards and votive deposits.* Cambridge: Cambridge University Press.

——(2000) *An archaeology of natural places.* London: Routledge.

BRANDT, R. W., and VAN DER LEEUW, S. E. (1987) 'Conclusions, Assendelver Polders'. In R. W. Brandt, W. Groenman-van Waateringe, and S. E. van der Leeuw (eds.), *Assendelver Polder Papers I.* Amsterdam: University Printing Office, 339–52.

BRAVARD, J. P., and MAGNY, M. (eds.) (2002) *Les fleuves ont une histoire: Paléo-environnement des rivières et des lacs français depuis 15000 ans.* Paris: Errance.

BREM, H. (2006) 'L'Économie dicte-t-elle la destruction ou la conservation des sites lacustres? La conservation "in situ" dans le canton de Thurgovie'. In D. Ramseyer and M.-J. Roulière-Lambert (eds.), *Archéologie et érosion—2: Zones humides en péril.* Lons-le-Saunier: Centre Jurassien du Patrimoine, 63–71.

——STEINER, D., and KESSELRING, R. (1999) 'Neues aus Tasgetium'. *Archäologie der Schweiz* 22 (3): 123–34.

BREUNIG, P., NEUMANN, K., and VAN NEER, W. (1996) 'New research on the Holocene settlement and environment of the Chad Basin in Nigeria'. *African Archaeological Review* 13: 111–45.

BROCK, F., HIGHAM, T. F. G., DITCHFIELD, P., and BRONK RAMSEY, C. (2010) 'Current pretreatment methods for AMS radiocarbon dating at the Oxford Radiocarbon Accelerator Unit (ORAU)'. *Radiocarbon* 52 (1): 103–12.

BROCKWELL, S. (1996) 'Open sites of the South Alligator River wetland, Kakadu'. In P. Veth and P. Hiscock (eds.), *Archaeology of Northern Australia.* St Lucia: Anthropology Museum, University of Queensland, 90–105.

——(2009) *Archaeological settlement patterns and mobility strategies: Lower Adelaide River, Northern Australia.* BAR International Series. Oxford: Archaeopress.

BRODIANSKI, D. L., and RAKOV, V. A. (1992) 'Prehistoric aquaculture on the western coast of the Pacific'. In C. M. Aikens and S. N. Rhee (eds.), *Pacific Northeast Asia in Prehistory: Hunter-fisher-gatherers, farmers, and sociopolitical elites.* Pullman: Washington State University Press, 27–31.

BROMBACHER, C., and JACOMET, S. (1997) 'Ackerbau, Sammelwirtschaft und Umwelt: Ergebnisse der archäobotanischen Untersuchungen'. In Monographien der Kantonsarchäologie Zürich (ed.), *Ökonomie und Ökologie neolithischer und bronzezeitlicher Ufersiedlungen am Zürichsee: Ergebnisse der Ausgrabungen Mozartstrasse, Kanalisationssanierung Seefeld, Akad und Mythenschloss in Zürich.* Zurich: Direktion der Öffentlichen Bauten des Kantons Zürich, 220–30.

BRONK RAMSEY, C. (2009) 'Bayesian analysis of radiocarbon dates'. *Radiocarbon* 51 (1): 337–60.

——BUCK, C. E., MANNING, S. W., REIMER, P., and VAN DER PLICHT, J. (2006) 'Developments in radiocarbon calibration for archaeology'. *Antiquity* 80: 783–98.

——VAN DER PLICHT, J., and WENINGER, B. (2001) '"Wiggle matching" radiocarbon dates'. *Radiocarbon* 43: 381–9.

Brooks, S. J. (2003) ‘Chironomidae (Insecta: Diptera)’. In A. MacKay, R. W. Battarbee, and H. J. B. Birks (eds.), *Global change in the Holocene*. London: Arnold

Brosius, J. P. (1997) ‘Endangered forest, endangered people’. *Human Ecology* 25: 47–69.

Brown, A. G. (2008) ‘Geoarchaeology, the four dimensional (4D) fluvial matrix and climatic casuality’. *Geomorphology* 101 (1–2): 278–97.

Brown, P., and Podolefsky, A. (1976) ‘Population density, agricultural intensity, land tenure and group size in the New Guinea Highlands’. *Ethnology* 15: 211–38.

Brown, T. (2003) ‘Divisions of floodplain space and sites on riverine “islands”: functional, ritual, social, or liminal places?’ *Journal of Wetland Archaeology* 3: 3–15.

——and Jones, G. E. M. (2001) ‘New ways with old wheats: molecular signatures from the past’. *Natural Environment Research Council* 9: 1–2.

Brück, J. (1999*a*) ‘Houses, life-cycles and deposition on Middle Bronze Age settlements in southern England’. *Proceedings of the Prehistoric Society* 65: 145–66.

——(1999*b*) ‘What’s in a settlement? Domestic practice and residential mobility in Early Bronze Age southern England’. In J. Brück and M. Goodman (eds.), *Making Places in the Prehistoric World. Themes in Settlement Archaeology*. London: UCL, 52–75.

Brunning, R. (1999) ‘The *in situ* preservation of the Sweet Track’. In B. J. Coles, J. M. Coles, and M. S. Jørgensen (eds.), *Bog Bodies, Sacred Sites and Wetland Archaeology*. Exeter: Wetland Archaeology Research Project, 33–8.

——(2007*a*) ‘Monitoring waterlogged sites in peatlands: where, how, why and what next?’ In J. W. Barber, C. Clark, M. Cressey, A. Crone, A. Hale, J. C. Henderson, R. A. Housley, R. Sands, and A. Sheridan (eds.), *Archaeology from the wetlands: Recent perspectives*. Edinburgh: Society of Antiquaries of Scotland, 41–7.

——(2007*b*) ‘Monuments at risk in Somerset’s peatlands’. In J. W. Barber, C. Clark, M. Cressey, A. Crone, A. Hale, J. C. Henderson, R. A. Housley, R. Sands, and A. Sheridan (eds.), *Archaeology from the wetlands: Recent perspectives.* Edinburgh: Society of Antiquaries of Scotland, 191–7.

Bruseth, J. E., Fehrenback, T. R., de La Salle, R. C., and Turner, T. S. (2005) *From a watery grave: The discovery and excavation of La Salle’s shipwreck,* La Belle. College Station: Texas A & M University Press.

Bryusov, A. Y. (1952) *Ocherki po Istorii Plemen Evropeiskoi Chasti SSSR v Neoliticheskuyu Epokhu.* Moscow: Izdatelstvo Akademii Nauk SSSR.

Brzezinski, W. (2001) ‘Poland’. In B. J. Coles and A. Olivier (eds.), *The heritage management of wetlands in Europe*. Exeter: Europae Archaeologiae Consilium and WARP, 65–70.

Buckland, P. C. (1979) *Thorne Moors: A palaeoecological study of a Bronze Age site (a contribution to the history of the British fauna).* Occasional Publication 8. Birmingham: Department of Geography, University of Birmingham.

Bull, J. M., Quinn, R., and Dix, J. K. (1998) ‘Reflection coefficient calculation from marine high resolution seismic reflection (chirp) data and application to an archaeological case study’. *Marine Geophysical Researches* 20: 1–11.

Bulleid, A., and Gray, H. S. B. (1911) *The Glastonbury Lake Village.* Glastonbury: Glastonbury Antiquarian Society.

——(1917) *The Glastonbury Lake Village.* Glastonbury: Glastonbury Antiquarian Society.

Bullen, R. P., and Jahn, O. L. (1978) *The Tick Island Site, St. Johns River, Florida.* Publication 10. Florida: Florida Anthropological Society.

Burov, G. M. (1989) ‘Some Mesolithic wooden artefacts from the site of Vis I in the European north east of U.S.S.R.’ In C. Bonsall (ed.), *The Mesolithic in Europe*. Edinburgh: John Donald, 391–401.

——(1998) ‘The use of vegetable materials in the Mesolithic of Northeast Europe’. In M. Zvelebil, L. Domańska, and R. Dennell (eds.), *Harvesting the sea, farming the forest: The emergence of Neolithic societies in the Baltic Region*. Sheffield: Sheffield Academic Press, 53–63.

——(2001) ‘Ancient wooden objects and structures in Oxbow peat bogs of the European Northeast (Russia)’. In B. A. Purdy (ed.), *Enduring records: The environmental and cultural heritage of wetlands*. Oxford: Oxbow, 215–32.

——(2009) ‘New types and categories of Mesolithic wooden artefacts from Vis I settlement in the Vychegda river basin’. *Rossiyskaya Archaeologiya* 2: 17–29.

Burri, E. (2005) ‘La céramique de Concise (VD) au Néolithique moyen et l’influence jurassienne’. *Archäologie Schweiz* 28 (3): 24–9.

——(2007) ‘Concise (Vaud, Suisse). Les vestiges céramiques d’un village du Néolithique moyen (3645–3636 av. J.-C.): répartitions spatiales et interprétations’. In M. Besse (ed.), *Sociétés néolithiques: Des faits archéologiques aux fonctionnements socio-économiques*. 153-64. Lausanne: Cahiers d’archéologie romande.

Butrimas, A. (1998) ‘Birzulio baseino ir Zemai i auk tumos akmens amziaus tyrin jim apzvalga’. *Lietuvos archeologija* 15: 107–31.

Buxton, R. (1991) *New Zealand’s wetlands: A management guide.* Wellington: Department of Conservation and Environmental Council.

Byram, S. (1998) ‘Fishing weirs in Oregon Coast estuaries’. In K. Bernick (ed.), *Hidden dimensions: The cultural significance of wetland archaeology*. Vancouver: University of British Columbia Press, 199–219.

Capelle, T. (1995) ‘Bronze Age stone ships’. In O. Crumlin-Pedersen and B. Munch Thye (eds.), *The ship as symbol in prehistoric and Medieval Scandinavia*. Copenhagen: Danish National Museum, 71–5.

——(2003) ‘Wooden idols from wetlands’. In A. Bauerochse and H. Haßmann (eds.), *Peatlands: Archaeological sites—archives of nature—nature conservation—wise use.* Rahden: Marie Leidorf, 126–31.

Caple, C., and Dungworth, D. (1997) ‘Investigations into waterlogged burial environments’. In A. Sinclair, E. Slater, and J. Gowlett (eds.), *Archaeological Sciences 1995*. Oxford: Oxbow, 233–40.

Cappellini, E., Gilbert, M. T. P., Geuna, F., Fiorentino, G., Hall, A., Thomas Oates, J., Ashton, P. D., Ashford, D. A., Arthur, P., Campos, P. F., Kool, J., Willerslev, E., and Collins, M. J. (2010) ‘A multidisciplinary study of archaeological grape seeds’. *Naturwissenschaften* 97: 205–17.

Cardarelli, A. (1997) ‘Terramare: l’organizzazione sociale e politica delle comunità’. In M. Bernabó Brea, A. Cardarelli, and M. Cremaschi (eds.), *Le terramare: La piùantica civiltà padana*. Milan: Electa, 653–60.

——and Tirabassi, J. (1997) ‘Le necropoli delle terramare emiliane’. In M. Bernabó Brea, A. Cardarelli, and M. Cremaschi (eds.), *Le terramare: La più antica civiltà padana*. Milan: Electa, 677–97.

CARDON, D. (2007) *Natural dyes. Sources, tradition, technology and science.* London: Archetype.

CARLSSON, T. (2008) *Where the river bends: Under the boughs of trees.* Oxford: Oxbow.

CARMACK, R., GASCO, J. L., and GOSSEN, G. H. (1996) *The legacy of Mesoamerica: History and culture of a native American civilization.* New Jersey: Prentice Hall.

CARSTENSEN, J., MEINERS, U., and MOHRMANN, R. E. (eds.) (2008) *Living history im Museum. Möglichkeiten und Grenzen einer populären Vermittlungsform.* Münster: Waxmann.

CASANA, J. J., and WILKINSON, T. J. (2005) 'Settlement and landscapes in the Amuq Region'. In K. Yener (ed.), *The archaeology of the Amuq Plain*. Chicago: Oriental Institute, 25–65.

CASPARIE, W. A. (1984) 'The three Bronze Age footpaths XVI (Bou), XVII (Bou) and XVIII (Bou) in the raised bog of southeast Drenthe (the Netherlands)'. *Palaeohistoria* 24: 41–94.

——(1986*a*) 'Houten veenwegen: prehistorisch vernunft?' *Natuur en Techniek* 54 (7): 507–19.

——(1986*b*) 'The two Iron Age wooden trackways XIV (Bou) and XV (Bou) in the raised bog of southeast Drenthe (the Netherlands)'. *Palaeohistoria* 28: 169–210.

——(1987) 'Bog trackways in the Netherlands'. *Palaeohistoria* 29: 35–65.

CASSELS, R. (1979) 'Early prehistoric wooden artefacts from the Waitore site (N136/16), near Patea, Taranaki'. *New Zealand Journal of Archaeology* 1: 85–108.

CASTALDO, E., CASTALDO, N., and CITRO, D. (2008) 'Dallo scavo alla ricostruzione ipotetica di una capanna della prima Eta' del Ferro: MAF 17 (Saggio 2A) a Langola di Poggiomarino'. In P. G. Guzzo and M. P. Guidobaldi (eds.), *Nuove ricerche archeologiche nell'area vesuviana (scavi 2003–2006).* Rome: L'erma di Bretschneider, 572–3.

CASTAÑEDA, Q. E. (2009) 'The past as transcultural space: Using ethnographic installation in the study of archaeology'. *Public Archaeology* 8 (2–3): 262–82.

——and MATTHEWS, C. N. (eds.) (2008) *Ethnographic archaeologies.* Lanham, Md.: Alta Mira.

CATALANI, P. (1984) 'Poggio Rusco (MN): la fauna'. *Preistoria Alpina* 20: 203–10.

CAUVIN, J. (2000) *The birth of the Gods and the origins of agriculture.* Cambridge: Cambridge University Press.

CAVEDONI, C. (1864) 'Primi cenni archeologici intorno a le terramare nostrane'. *AMDSP* 2: 423–32.

CAVERS, G. (2007) 'The complexity of crannog taphonomy: old and new evidence'. In J. W. Barber, C. Clark, M. Cressey, A. Crone, A. Hale, J. C. Henderson, R. A. Housley, R. Sands, and A. Sheridan (eds.), *Archaeology from the wetlands: Recent perspectives*. Edinburgh: Society of Antiquaries of Scotland, 243–52.

CHABANUK, V. (2008) 'New experimental data on the Tripolye house construction techniques'. In A. G. Korvin-Piotrovskiy and F. Menotti (eds.), *Tripolye culture in Ukraine: The giant-settlement of Talianki*. Kiev: Korvin, 218–26.

CHAIRKINA, N. M. (2005) *Eneolit Srednego Zauralya.* Yekaterinburg: Uralskoe Otdelenie Rossiiskoi Akademii Nauk.

——SAVCHENKO, S. N., SERIKOV, Y. B., and LITVYAK, A. S. (2001) *Arkheologicheskie Pamyatniki Shigirskogo Torfyanika.* Yekaterinburg: Bank Kulturnoi Informatsii.

Chaix, L. (2003) 'A short note on the Mesolithic fauna from Zamostje 2 (Russia)'. In L. Larsson, H. Kindgren, K. Knutsson, D. Loeffler, and A. Åkerlund (eds.), *Mesolithic on the move*. Oxford: Oxbow, 645–48.

Chamberlain, A. T. (2006) *Demography in archaeology*. Cambridge: Cambridge University Press.

Chaney, G. (1998) 'The Montana Creek Fish Trap II: stratigraphic interpretation in the context of Southeastern Alaska geomorphology'. In K. Bernick (ed.), *Hidden dimensions: The cultural significance of wetland archaeology*. Vancouver: University of British Columbia Press, 252–66.

Chang, K.-C. (1986) *The archaeology of Ancient China*. New Haven: Yale University Press.

Chapman, H. P., and Cheetham, J. L. (2002) 'Monitoring and modelling saturation as a proxy indicator for *in situ* preservation in wetlands: a GIS-based approach'. *Journal of Archaeological Science* 29: 277–89.

——and Gearey, B. R. (2002) 'Archaeological predictive modelling in raised mires—concerns and approaches for their interpretation and future management'. *Journal of Wetland Archaeology* 2: 77–88.

——and van de Noort, R. (2001) 'High resolution wetland prospection, using GPS and GIS: landscape studies at Sutton Common (South Yorkshire) and Meare Village East (Somerset)'. *Journal of Archaeological Science* 28: 365–75.

Charman, D. J., Blundell, A., and ACCROTELM Members (2007) 'A new European testate amoebae transfer function for palaeohydrological reconstruction on ombrotrophic peatlands'. *Journal of Quaternary Science* 22: 203–21.

Charniauski, M. M. (1997) 'The Northern Belarusian culture'. In Bielaruskaja Navuka (ed.), *Archaeology of Belarus: Stone and Bronze Ages*. Minsk: Belaruskaja Navuka, 311–29.

——(2006) 'Complex of Ceramic from Asaviec 7 site'. *Historical-Archaeological Collection* 21: 38–47.

——(2007) *Bone and Horn Articles at the Settlements of Kryvina Peat Bog (Neolithic–Early Bronze Age*. Minsk: Belaruskaja Navuka.

Chiba, T. (2009) *The Lacquer Village of the Jomon period—Shimoyakebe Site.* Shinsen-sha: ASIC.

Childe, V. G. (1957) *The Prehistory of European society.* Harmondsworth: Penguin.

Christensen, C. (1990) 'Stone Age dug-out boats in Denmark: Occurrence, age, form and reconstruction'. In D. E. Robinson (ed.), *Experimentation and reconstruction in environmental archaeology*. Oxford: Oxbow, 119–41.

——(1999) 'Mesolithic boats from around the Great Belt, Denmark'. In B. J. Coles, J. M. Coles, and M. S. Jørgensen (eds.), *Bog bodies, sacred sites and wetland archaeology*. Exeter: Wetland Archaeology Research Project, 47–50.

Cicirelli, C., and Albore Livadie, C. (2008) 'Stato delle ricerche a Longola di Poggiamarino: quadro insediamentale e problematiche'. In P. G. Guzzo and M. P. Guidobaldi (eds.), *Nuove ricerche archeologiche nell'area vesuviana (scavi 2003–2006).* Rome: L'erma di Bretschneider, 473–87.

Clare, T., Clapham, A. J., Wilkinson, D. M., and Haworth, E. Y. (2001) 'The Mesolithic and Neolithic landscapes of Barfield Tarn and Eskmeals in the English Lake District:

Some new evidence from two different wetland contexts'. *Journal of Wetland Archaeology* 1: 83–105.

CLARK, J. G. D. (1954) *Excavations at Star Carr.* Cambridge: Cambridge University Press.

——(1972) *Star Carr. A case study in bioarchaeology.* Massachusetts: Addison-Wesley.

CLARK, P. (2004) 'The Dover boat ten years after its discovery'. In P. Clark (ed.), *The Dover Bronze Age boat in context: Society and water transport in prehistoric Europe.* Oxford: Oxbow, 1–12.

CLARKE, D. L. (1976) 'Mesolithic Europe: the economic basis'. In D. Sieveking, I. Longworth, and K. Wilson (eds.), *Problems in economic and social archaeology*. London: Duckworth, 449–81.

CLAUSEN, C. J., BROOKS, H. K., and WESOLOWSKY, A. B. (1975) 'The early man site at Warm Mineral Springs, Florida'. *Journal of Field Archaeology* 2: 191–213.

——COHEN, A. D., EMILIANI, C., HOLMAN, J. A., and STIPP, J. J. (1979) 'Little Salt Spring, Florida: A unique underwater site'. *Science* 203: 609–14.

CLAVIR, M. (2002) *Preserving what is valued: museums, conservation, and First Nations: A comparative study.* Vancouver: University of British Columbia Press.

CLÉMENT, B., and PROCTOR, M. C. F. (2009) 'Ecological dynamics I: Vegetation as bioindicator and dynamic community'. In E. Maltby and T. Barker (eds.), *The wetlands handbook.* Oxford: Blackwell, 282–303.

CLERC, J., MAGNY, M., and MOUTHON, J. (1989) 'Histoire d'un milieu lacustre du Bas-Dauphiné: Le Grand-Lemps. Étude palynologique des remplissages tardiglaciaires et holocènes et mise en évidence de fluctuations lacustres à l'aide d'analyses sédimentologiques et malacologiques'. *Revue de Paléobiologie* 8: 1–19.

CLOSE, A. E. (1996) 'Plus ça change: The Pleistocene-Holocene transition in Northeast Africa'. In L. G. Straus, B. V. Eriksen, J. M. Erlandson, and D. R. Yesner (eds.), *Humans at the end of the Ice Age: The archaeology of the Pleistocene-Holocene Transition*. New York: Plenum, 43–60.

COGGINS, C. C. (2001) 'A soft economy: Perishable artifacts offered to the well of sacrifice, Chichén Itzá'. In B. A. Purdy (ed.), *Enduring records: The environmental and cultural heritage of wetlands*. Oxford: Oxbow, 83–91.

COLARDELLE, M., and VERDEL, E. (1993) *Les Habitats du lac de Paladru (Isere) dans leur environment.* Paris: Maison des Sciences.

COLE, S. (1994) 'Marsh formation in the Borsippa region and the course of the lower Euphrates'. *Journal of Near Eastern Studies* 53: 81–109.

COLES, B. J. (1988) 'Fossil insect assemblages from the Somerset Levels: The work of Maureen Girling'. In P. Murphy and C. French (eds.), *The exploitation of wetlands.* BAR BritishSeries 186. Oxford: Archaeopress, 5–20.

——(1990) 'Anthropomorphic wooden figures from Britain and Ireland'. *Proceedings of the Prehistoric Society* 56: 315–33.

——(1993) 'Ross Carr and company'. In J. M. Coles, V. Fenwick, and G. Hutchinson (eds.), *A spirit of enquiry. Essays for Ted Wright*. Exeter: Wetland Archaeology Research Project, 17–22.

——(1995) *Wetland Management: A survey for English Heritage.* Exeter: WARP.

——(1998) 'Doggerland: A speculative survey'. *Proceedings of the Prehistoric Society* 64: 45–82.

——(1999*a*) 'Doggerland's loss and the Neolithic'. In B. J. Coles, J. M. Coles, and M. S. Jørgensen (eds.), *Bog bodies, sacred sites and wetland archaeology*. Exeter: Wetland Archaeology Research Project, 51–7.

——(1999*b*) 'Somerset and the Sweet conundrum'. In A. Harding (ed.), *Experiment and design: Archaeological studies in honour of John Coles*. Oxford: Oxbow, 163–9.

——(2001) 'Britain and Ireland'. In B. J. Coles and A. Olivier (eds.), *The heritage management of wetlands in Europe*. Exeter: Europae Archaeologiae Consilium and WARP, 23–34.

——(2003) 'An archaeological approach to the study of European beaver and their significance in past wetland ecosystems'. In A. Bauerochse and H. Haßmann (eds.), *Peatlands: Archaeological sites—archives of nature—nature conservation—wise use*. Rahden: Marie Leidorf, 25–35.

——(2004) 'Steps towards the heritage management of wetlands in Europe'. *Journal of Wetland Archaeology* 4: 183–98.

——and Coles, J. M. (1986) *Sweet Track to Glastonbury: The prehistory of the Somerset Levels*. London: Thames & Hudson.

——(1989) *People of the wetlands: Bogs, bodies and lake-dwellers*. London: Thames & Hudson.

——and Olivier, A. (eds.) (2001) *The heritage management of wetlands in Europe*. Exeter: Europae Archaeologiae Consilium and WARP.

——Coles, J. M., and Jørgensen, M. S. (eds.) (1999) *Bog bodies, sacred sites and wetland archaeology*. Exeter: Short Run.

Coles, J. M. (1962) 'European Bronze Age shields'. *Proceedings of the Prehistoric Society* 28: 156–90.

——(1973) *Archaeology by experiment*. London: Hutchinson.

——(1979) *Experimental archaeology*. London: Academic Press.

——(1980) 'The Abbot's Way 1979'. *Papers* 6: 46–9.

——(1984) *The archaeology of wetlands*. Edinburgh: Edinburgh University Press.

——(1987) *Meare Village East: Excavations of A. Bulleid and H. St. George Gray 1932–1956*. Hertford: Somerset Levels Project.

——(2001*a*) 'Of water-wings and wellingtons: Wetland archaeology and the new journal'. *Journal of Wetland Archaeology* 1: 3–13.

——(2001*b*) 'Wetlands, archaeology and conservation at AD 2001'. In B. J. Coles and A. Olivier (eds.), *The heritage management of wetlands in Europe*. Exeter: Europae Archaeologiae Consilium and WARP, 171–84.

——and Coles, B. J. (1996) *Enlarging the past*. Exeter: Short Run.

——and Hall, D. (1998) *Changing landscapes: The ancient Fenland*. Cambridge: Cambridgeshire County Council.

——and Minnitt, S. (1995) *Industrious and fairly civilised, the Glastonbury lake village*. Tauton: Somerset Levels Project and Somerset County Council Museum Service.

——and Orme, B. J. (1976) 'The Meare Heath Trackway: Excavation of a Bronze Age Structure in the Somerset Levels'. *Proceedings of the Prehistoric Society* 42: 293–318.

——(1980) *Prehistory of the Somerset Levels*. Hertford: Somerset Levels Project.

——(1984*a*) 'A reconstruction of the Sweet Track'. *Somerset Levels Papers* 10: 107–9.

Coles, J. M. (1984*b*) 'Ten excavations along the Sweet Track (3200 bc)'. *Papers* 10: 5–45.

——Goodall, A., and Minnitt, S. (1992) *Arthur Bulleid and the Glastonbury Lake Village.* Taunton: Somerset Levels Project and Somerset County Council Museums Service.

Colledge, S., and Conolly, J. (2007) *The origins and spread of domestic plants in southwest Asia and Europe*. Walnut Creek, Calif.: Left Coast.

Collins, J. (2008) 'Facing the future, touching the past: An exploration of visitor responses to wetland archaeological sites'. *Journal of Wetland Archaeology* 8: 73–90.

Colwell-Chanthaphonh, C., and Ferguson, T. J. (eds.) (2008) *Collaboration in archaeological practice.* Lanham, Md.: Rowman & Littlefield.

Connaway, J. M. (2007) *Fishweirs: A world perspective with emphasis on the fishweirs of Mississippi.* Jackson: Mississippi Department of Archives and History Archaeologica.

Cook, C., and Grattan, D. W. (1985) 'A practical comparative study of treatments for waterlogged wood: Part III: Pretreatment solutions for freeze-drying'. In Centre d'Étude et de Traitement des Bois Gorgés d'Eau (ed.), *Les Bois Gorgés d'Eau—waterlogged wood. Proceedings of the 2nd ICOM Waterlogged Wood Working Group Conference, Grenoble, 1984*. Grenoble: Centre d'Étude et de Traitement des Bois Gorgés d'Eau, 219–39.

——(1991) 'A method for calculating the concentration of PEG for freeze-drying waterlogged wood'. In P. Hoffman (ed.), *Proceedings of the 4th ICOM Group on Wet Organic Archaeological Materials Conference, Bremerhaven 1990*. Bremerhaven: ICOM Committee for Conservation Working Group on Wet Organic Archaeological Materials, 239–52.

Cook, G. T., Dixon, T. N., Russell, N., Naysmith, P., Xu, S., and Andrian, B. (2010) 'High-precision radiocarbon dating of the construction phase of Oakbank Crannog, Loch Tay, Perthshire'. *Radiocarbon* 52 (2): 346–55.

Cook, H. (1999) 'Soil and water management: Principles and purposes'. In H. Cook and T. Williamson (eds.), *Water management in the English landscape, field marsh and meadow*. Edinburgh: Edinburgh University Press, 15–27.

Cooney, G. (1997) 'Images of settlement and the landscape in the Neolithic'. In P. Topping (ed.), *Neolithic Landscapes*. Oxford: Oxbow, 23–31.

——(2000) *Landscapes of Neolithic Ireland*. London: Routledge.

Coope, G. R., and Osborne, P. J. (1968) 'Report on the coleopterous fauna of the Roman Well at Barnsley Park, Gloucestershire'. *Transactions of the Bristol and Gloucestershire Archaeological Society* 86: 84–7.

Copeland, T. (2006) 'Constructing pasts: interpreting the historic environment'. In A. Hems and M. Blockley (eds.), *Heritage interpretation*. London: Routledge, 83–95.

Coppers, R. T. J., and Bottema, S. (eds.) (2002) *The dawn of farming in the Near East.* Berlin: Ex Oriente.

Corfield, M. (1996) 'Preventive conservation for archaeological sites'. In A. Roy and P. Smith (eds.), *Archaeological conservation and its consequences*: London: International Institute for Conservation of Historic and Artistic Works, 32–7.

——(1998) 'The role of monitoring in the assessment and management of archaeological sites'. In K. Bernick (ed.), *Hidden dimensions: The cultural significance of wetland archaeology*. Vancouver: University of British Columbia Press, 302–18.

——(2007) 'Wetland science'. In M. Lillie and S. Ellis (eds.), *Wetland archaeology & environments: Regional issues, global perspectives*. Oxford: Oxbow, 143–55.

Cowell, R., and Innes, J. B. (1994) *The wetlands of Merseyside—North West Wetland Survey*. Lancaster: Lancaster Imprints.

Cox, C. (1992) 'Satellite imagery, aerial photography and wetland archaeology'. *World Archaeology* 24 (2): 249–67.

Cox, M. (1995) 'Peatland restoration and rehabilitation: Ecological gain and archaeological loss?' In M. Cox, V. Straker, and D. Taylor (eds.), *Wetlands: Archaeology and nature conservation*. London: HMSO, 115–27.

——Starker, V., and Taylor, D. (eds.) (1995) *Wetlands: Archaeology and nature conservation*. London: HMSO.

Crawshaw, A. (2009) 'Computer modelling of polyethylene glycol (PEG) degradation'. In K. Straetkvern and D. J. Huisman (eds.), *Proceedings of the 10th ICOM Group on Wet Organic Archaeological Materials Conference, Amsterdam 2007*. Amersfoort: ICOM Committee for Conservation Working Group on Wet Organic Archaeological Materials, 367–70.

Cremaschi, M. (1997) 'Terramare e paesaggio padano'. In M. Bernabó Brea, A. Cardarelli, and M. Cremaschi (eds.), *Le terramare: La più antica civiltà padana*. Milan: Electa, 107–25.

——Pizzi, C., and Valsecchi, V. (2006) 'Water management and land use in the terramare and a possible climatic co-factor in their abandonment: The case study of the terramare of Poviglio Santa Rosa (northern Italy)'. *Quaternary International* 151: 87–98.

Croes, D. R. (ed.) (1976) *The excavation of water saturated archaeological sites (wet site) on the Northwest Coast of North America*. Ottawa: National Museum of Man Mercury.

——(1992) 'An evolving revolution in wet site research on the Northwest Coast of North America: The example of Windover'. In B. J. Coles (ed.), *The Wetland Revolution in Prehistory*. Exeter: The Prehistoric Society, 99–111.

——(1995) *The Hoko River archaeological site complex: The Wet/dry site (45CA 213), 3000–1700 BP*. Pullman: Washington State University Press.

——(1997) 'The north-central cultural dichotomy on the Northwest Coast of North America: Its evolution as suggested by wet-site basketry and wooden fish-hooks'. *Antiquity* 71: 594–615.

——(1999) 'The Hoko River wet site. A joint tribe/university research effort'. In B. J. Coles, J. M. Coles, and M. S. Jørgensen (eds.), *Bog bodies, sacred sites and wetland archaeology*. Exeter: Wetland Archaeology Research Project, 59–66.

——(2001) 'Birth to death: Northwest Coast wet site basketry and cordage artifacts reflecting a person's life cycle'. In B. A. Purdy (ed.), *Enduring records: The environmental and cultural heritage of wetlands*. Oxford: Oxbow, 92–109.

——(2003) 'Northwest Coast wet-site artifacts: A key to understanding resource procurement, storage, management, and exchange'. In R. G. Matson, G. Coupland, and Q. Mackie (eds.), *Emerging from the mist: Studies in Northwest Coast culture history*. Vancouver: UBC, 51–75.

——(2010) 'Courage and thoughtful scholarship = Indigenous archaeology partnerships'. *American Antiquity* 75 (2): 211–16.

CROES, D. R. FAGAN, J. L., and NEWMAN ZEHENDNER, M. (2009) 'Sunken Village, Sauvie Island, Oregon, USA: A report on the 2006–2007 investigations of National Historic Landmark wet site 35MU4'. *Journal of Wetland Archaeology* 9 (Special Edition): 1–216.

——and FOSTER, R. (2003) 'Perishable artifacts from Northwest Coast sites—a critical need for Native American expertise'. In Wetland Archaeology Research Project (ed.), *Wet Sites Connections*. Exeter: Wetland Archaeology Research Project, 2–7.

——KELLY, K. M., and COLLARD, M. (2005) 'Cultural historical context of Qwu?gwes (Puget Sound, USA): A preliminary investigation'. *Journal of Wetland Archaeology* 5: 141–54.

————ROSS, L., DIEDRICH, M., HUBBARD, N., KELLY, K., MCCULLOUGH, M., MCCULLOUGH, T., MYERS, K., SHARRON, C., VARGO, B., and WIGEN, R. (2007) 'Qwu?,gwes: a Squaxin Island tribal heritage wet site, Puget Sound, USA'. In J. W. Barber, C. Clark, M. Cressey, A. Crone, A. Hale, J. C. Henderson, R. A. Housley, R. Sands, and A. Sheridan (eds.), *Archaeology from the wetlands: Recent perspectives*. Edinburgh: Society of Antiquaries of Scotland, 135–53.

CRONE, A. (1993) 'Crannogs and chronologies'. *Proceedings of the Society of Antiquaries of Scotland* 123: 245–54.

——(2000) *The history of a Scottish Lowland crannog: Excavations at Buiston, Ayrshire 1989–90.* Edinburgh: Scottish Trust for Archaeological Research.

CRUMLEY, C. L. (ed.) (1994) *Historical Ecology: Cultural knowledge and changing landscapes.* Santa Fe: School of American Research Press.

CULBERT, T. P. (1983) 'Mesoamerica'. In J. D. Jennings (ed.), *Ancient North America.* San Francisco: W. H. Freeman Co., 495–555.

CUNLIFFE, B. W. (2001) *Facing the ocean: The Atlantic and its people.* Oxford: Oxford University Press.

CUSHING, F. H. (1897) 'Exploration of ancient Key Dwellers' remains on the Gulf Coast of Florida'. *Proceedings of the American Philosophical Society* 25: 329–448.

CZEBRESZUK, J. (2005) 'A Polish-German research project into a Bronze Age fortified settlement at Bruszczewo'. *Archaeologia Polona* 43: 175–200.

D'ANDREA, A. C., CRAWFORD, G. W., YOSHIZAKI, M., and KUDO, T. (1995) 'Late Jomon cultigens in northeastern Japan'. *Antiquity* 69: 146–52.

DAUGHERTY, R. D., and FRIEDMAN, J. (1983) 'An introduction to Ozette Art'. In R. L. Carlson (ed.), *Indian art traditions of the Northwest Coast*. Burnaby: Archaeology Press, 183–95.

DAVIDSON, J. M. (1984) *The prehistory of New Zealand.* Auckland: Longman Paul.

DAVIES, C. P. (2006) 'Holocene paleoclimates of southern Arabia from lacustrine deposits of the Dhamar highlands, Yemen'. *Quaternary Research* 66: 454–64.

DAVIS, A. M., MCANDREWS, J. H., and WALLACE, B. L. (1988) 'Paleoenvironment and the archaeological record at the L'Anse aux Meadows Site, Newfoundland'. *Geoarchaeology* 1: 53–64.

DAVIS, K., and BERNSTAM, M. S. (eds.) (1990) *Resources, environment and population: Present knowledge, future options.* New York: Oxford University Press.

DAVIS, S. R., BROWN, A. G., and DINNIN, M. H. (2007) 'Floodplain connectivity, disturbance and change: A palaeoentomological investigation of floodplain ecology from south-west England'. *Journal of Animal Ecology* 76: 276–88.

De Bry, T. (1590–1634) *Collectiones peregrinatiorum in Indiam orientalem et Indiam occidentalem, XIII partibus comprehenso.* Frankfurt: Matheo Merian.

De Capitani, A., and Leuzinger, U. (1998) 'Arbon-Bleiche 3: Siedlungsgeschichte, einheimische Traditionen und Fremdeinflüsse im Übergangsfeld zwischen Pfyner und Horgener Kultur'. *Jahrbuch der Schweizerischen Gesellschaft für Ur- und Frühgeschichte* 81: 237–49.

——Deschler-Erb, S., Leuzinger, U., Marti-Grädel, E., and Schibler, J. (2002) *Die jungsteinzeitliche Seeufersiedlung Arbon Bleiche 3. Funde. Archäologie im Thurgau.* Frauenfeld: Amt für Archäologie des Kanton Thurgau.

De Geer, G. (1912) 'A geochronology of the last 12,000 years'. *XI International Geological Congress, Stockholm* 1: 241–53.

De Grossi Mazzorin, J. (2004) 'Some considerations about the evolution of the animal exploitation in Central Italy from the Bronze Age to the Classical period'. In B. S. Frizell (ed.), *PECUS. Man and animal in Antiquity*. Rome: Swedish Institute in Rome, 38–49.

——and Riedel, A. (1997) 'La fauna delle terramare'. In M. Bernabó Brea, A. Cardarelli, and M. Cremaschi (eds.), *Le terramare: La più antica civiltà padana*. Milan: Electa, 475–80.

De Marinis, R. C. (1998) 'La metallurgia nell'Antica e Media eta' del Bronzo in Piemonte'. In L. Mercando and M. Venturino Gambari (eds.), *Archeologia in Piemonte I. La preistoria*:. Turin: Marchi, 157–86.

——(2006) 'Circolazione del metallo e dei manufatti nell'età del Bronzo dell'Italia settentrionale'. In Istituto Italiano di Preistoria e Protostoria (ed.), *Atti della XXXIX riunione scientifica: materie prime e scambi nella preistoria italiana*. Florence: Istituto Italiano di Preistoria e Protostoria, 1289–318.

——Rapi, M., Scandol, M., Balista, C., Marziani, G., Iannone, A., and Camagni, B. M. (1994) 'La terramara dell'età del Bronzo Recente di Ca' de' Cessi (Sabbioneta, Mantova)'. *Sibrium* 22: 43–96.

Dean, J. S. (1989) 'Dendrochronology and paleoenvironmental reconstruction on the Colorado Plateau'. In G. Gumerman (ed.), *The Anasazi in a changing environment*. Cambridge: Cambridge University Press, 119–67.

Décima, E. B., and Dincauze, D. F. (1998) 'The Boston Back Bay fish weirs'. In K. Bernick (ed.), *Hidden dimensions: The cultural significance of wetland archaeology*. Vancouver: University of British Columbia Press, 157–72.

Deguilloux, M.-F., Bertel, L., Celant, A., Pemonge, M. H., Sadori, L., Magri, D., and Petit, R. J. (2006) 'Genetic analysis of archaeological wood remains: First results and prospects'. *Journal of Archaeological Science* 33 (9): 1216–27.

Deichmüller, J. (1975) 'Die jungsteinzeitliche Moorsiedlung Hüde I am Dümmer'. *Telma* 5: 43–50.

Delcourt, H. R., Delcourt, P. A., and Royall, P. D. (1997) 'Late Quarternary vegetational history of the Western Lowlands'. In D. F. Morse (ed.), *Sloan: A Paleoindian Dalton Cemetery in Arkansas*. Washington, DC: Smithsonian, 103–22.

Denevan, W. (1996) 'A bluff model of riverine settlement in prehistoric Amazonia'. *Annals of the Association of American Geographers* 86: 654–81.

——(1970) 'Aboriginal drained-field cultivation in the Americas'. *Science* 169 (3946): 647–54.

Denevan, W. (2002) *Cultivated landscapes of native Amazonia and the Andes*. Oxford: Oxford University Press.

Denham, T. (2005) 'Agricultural origins and the emergence of rectilinear ditch networks in the highlands of New Guinea'. In A. Pawley, R. Attenborough, J. Golson, and R. Hide (eds.), *Papuan pasts: Cultural, linguistic and biological histories of Papuan-speaking peoples*. Canberra: The Australian National University, 329–61.

——(2007) 'Early to Mid-Holocene plant exploitation in New Guinea: Towards a contingent interpretation of agriculture'. In T. Denham, J. Iriarte, and L. Vrydaghs (eds.), *Rethinking agriculture: Archaeological and ethnoarchaeological perspectives*. Walnut Creek, Calif.: Left Coast, 78–108.

Denham, T., Fullagar, R., and Head, L. (2009) 'Plant exploitation on Sahul: From colonisation to the emergence of regional specialisation during the Holocene'. *Quaternary International* 202 (1–2): 29–40.

——Haberle, S. G., and Lentfer, C. (2004) 'New evidence and revised interpretations of early agriculture in Highland New Guinea'. *Antiquity* 78: 839–57.

————————Fullagar, R., Field, J., Therin, M., Porch, N., and Winsborough, B. (2003) 'Origins of agriculture at Kuk Swamp in the Highlands of New Guinea'. *Science* 301: 189–93.

Dennell, R. (1985) 'The hunter-gatherer agricultural frontiers in prehistoric temperate Europe'. In S. Green and S. M. Perlman (eds.), *The archaeology of frontiers and boundaries*. New York: Academic Press, 113–40.

Denny, P. (1991) 'Africa'. In M. Finlayson and M. Moser (eds.), *Wetlands*. Oxford: International Waterfowl and Wetlands Research Bureau, 115–48.

——(1995) 'Benefits and priorities for wetland conservation: The case for national wetland conservation strategies'. In M. Cox, V. Straker, and D. Taylor (eds.), *Wetlands: Archaeology and nature conservation*. London: HMSO, 249–74.

Deschler-Erb, S., and Marti-Grädel, E. (2004*a*) 'Hinweise zur Schichterhaltung aufgrund der Tierknochen'. In S. Jacomet, U. Leuzinger, and J. Schibler (eds.), *Die jungsteinzeitliche Seeufersiedlung Arbon-Bleiche 3*. Frauenfeld: Veröffentlichung des Amtes für Archäologie des Kantons Thurgau, 90–100.

————(2004*b*) 'Viehhaltung und Jagd. Ergebnisse der Untersuchung der handaufgelesenen Tierknochen'. In S. Jacomet, U. Leuzinger, and J. Schibler (eds.), *Die jungsteinzeitliche Seeufersiedlung Arbon-Bleiche 3*. Frauenfeld: Veröffentlichung des Amtes für Archäologie des Kantons Thurgau, 158–252.

————and Schibler, J. (2002) 'Die Knochen-, Zahn- und Geweihartefakte'. In A. De Capitani, S. Deschler-Erb, U. Leuzinger, E. Marti-Grädel, and J. Schibler (eds.), *Die jungsteinzeitliche Seeufersiedlung Arbon Bleiche 3: Funde.* Frauendeld: Departement für Erziehung und Kultur des Kantons Thurgau, 277–366.

Desor, E. (1865) *Les Palafittes ou constructions lacustres du lac de Neuchâtel.* Paris: Libraire Éditeur.

Develle, A.-L., Herreros, J., Vidal, L., Sursock, A., and Gasse, F. (2010) 'Controlling factors on a paleo-lake oxygen isotope record (Yammouneh, Lebanon) since the Last Glacial Maximum'. *Quaternary Science Reviews* 29: 865–86.

Dieckmann, B. (1989) 'Eine Siedlung der ausgehenden Frühbronzezeit bei Hilzingen, Kreis Konstanz'. *Archäologische Ausgrabungen in Baden-Württemberg* 1989: 53–8.

——(1990) 'Sondage in den mittelbronzezeitlichen Siedlungen von Hilzingen, Rielasingen-Worblingen und Hilzingen-Duchtlingen, Kreis Konstanz'. *Archäologische Ausgrabungen in Baden-Württemberg* 1990: 56–62.

——Harwarth, A., and Hoffstadt, J. (2006) 'Hornstaad-Hörnle IA: Die Befunde einer jungneolitischen Pfahlbausiedlung am westlichen Bodensee'. In Landesamt für Denkmalpflege (ed.), *Siedlungsarchäologie im Alpenvorland IX*: 8-276. Stuttgart: Konrad Theiss.

——Maier, U., and Vogt, R. (1997) 'Hornstaad-Hörnle, eine der ältesten jungsteinzeitlichen Ufersiedlungen am Bodensee'. In H. Schlichtherle (ed.), *Pfahlbauten rund um die Alpen*. Stuttgart: Konrad Theiss, 15–21.

Dierßen, K. (2003) 'Ecology and vegetation of peatlands'. In A. Bauerochse and H. Haßmann (eds.), *Peatlands: Archaeological sites—archives of nature—nature conservation—wise use*. Rahden: Marie Leidorf, 196–209.

Dietrich, M. (2003) 'The wooden figures from Braak in the district of Ostholstein reconsidered'. In A. Bauerochse and H. Haßmann (eds.), *Peatlands: Archaeological sites—archives of nature—nature conservation—wise use*. Rahden: Marie Leidorf, 163–9.

Digerfeldt, G. (1986) 'Studies on past lake-level fluctuations.' In B. E. Berglund (ed.), *Handbook of Holocene palaeoecology and palaeohydrology*. New York: John Wiley & Sons, 127–43.

Dillehay, T. D. (1989) *Monte Verde: A Late Pleistocene settlement in Chile*. Washington, DC: Smithsonian I.

——(1997) *Monte Verde: A Late Pleistocene settlement in Chile*. Washington, DC: Smithsonian.

——Quivira, M. P., Bonzani, R., Silva, C., Wallner, J., and Le Quesne, C. (2007) 'Cultivated wetlands and emerging complexity in South-Central Chile and long distance effects of climate change'. *Antiquity* 81 (314): 949–96.

Dinnin, M., and Van de Noort, R. (1999) 'Wetland habitats, their resource potential and exploitation. A case study from the Humber wetlands'. In B. J. Coles, J. M. Coles, and M. S. Jørgensen (eds.), *Bog bodies, sacred sites and wetland archaeology*. Exeter: Wetland Archaeology Research Project, 69–78.

Dise, N. B. (2009) 'Biogeochemical dynamics III: The critical role of carbon in wetlands'. In E. Maltby and T. Barker (eds.), *The wetlands handbook*. Oxford: Blackwell, 249–65.

Dixon, E. J. (1999) *Bones, boats and bisons.* Albuquerque: University of New Mexico Press.

Dixon, N. (2004) *The crannogs of Scotland. An underwater archaeology.* Stroud: Tempus.

——(2007) 'Crannog structure and dating in Perthshire with particular reference to Loch Tay'. In J. W. Barber, C. Clark, M. Cressey, A. Crone, A. Hale, J. C. Henderson, R. A. Housley, R. Sands, and A. Sheridan (eds.), *Archaeology from the wetlands: Recent perspectives*. Edinburgh: Society of Antiquaries of Scotland, 253–65.

Dobney, K., and G. Larson (2006) 'Genetics and animal domestication: New windows on an elusive process'. *Journal of Zoology* 269: 261–71.

Dolukhanov, P. (1992) 'Evolution of lakes and prehistoric settlement in Northwestern Russia'. In B. J. Coles (ed.), *The wetland revolution in prehistory*. Exeter: Prehistoric Society, 93–8.

Dolukhanov, P. and Mazurkevich, A. (2000) 'Sites lacustres neolithiques de Russie'. *Archeologia* 369: 69–70.

——Shukurov, A., Arslanov, K., Mazurkevich, A. N., Savel´eva, L. A., Dzinoridze, E. N., Kulkova, M. A. and Zaitseva, G. I. (2004) 'The Holocene Environment and Transition to Agriculture in Boreal Russia (Serteya Valley Case Study)'. *Internet Archaeology* 2004 (17), <http://intarch.ac.uk/journal/issue17>, accessed July 2011.

Domańska, L. (1998) 'The initial stage of food-production in Polish Lowlands—the Deby 29 site'. In M. Zvelebil, L. Domańska, and R. Dennell (eds.), *Harvesting the sea, farming the forest: The emergence of Neolithic societies in the Baltic Region*. Sheffield: Sheffield Academic Press, 129–33.

——(2003) 'Interactions between the late Mesolithic hunter-gatherers and farming communities in Northern Poland'. In L. Larsson, H. Kindgren, K. Knutsson, D. Loeffler, and A. Åkerlund (eds.), *Mesolithic on the move* Oxford: Oxbow, 588–91.

Doppler, T., Pichler, S., Jacomet, S., Schibler, J., and Röder, B. (2010) 'Archäobiologie als sozialgeschichtliche Informationsquelle: ein bisland vernachlässigtes Forschungspotential'. In E. Classen, T. Doppler, and B. Ramminger (eds.), *Familie—Verwandtschaft—Sozialstrukturen. Sozialarchäologische Forschungen zu neolithischen Befunden*. Kerpen-Loogh: Welt & Erde, 119–39.

——Pollmann, B., Pichler, S., Jacomet, S., Schibler, J., and Röder, B. (2011) 'Bauern, Fischerinnen und Jäger: Unterschiedliche Ressourcen- und Landschaftsnutzung in der neolithischen Siedlung Arbon Bleiche 3'. In J. Studer, M. David-Elbiali, and M. Besse (eds.), *Paysage*. Lausanne: Cahiers d'Archéologie Romande, 143–58.

Doran, G. H. (2001*a*) 'The view from Windover: 15 years after excavation'. In B. A. Purdy (ed.), *Enduring records: The environmental and cultural heritage of wetlands*. Oxford: Oxbow, 9–17.

——(2001*b*) *The Windover Archaeological Research Project.* Orlando: Florida University Press.

——(ed.) (2002) *Windover: Multidisciplinary investigations of an Early Archaic Florida cemetery.* Gainesville: University Press of Florida.

——and Dickel, D. N. (1988) 'Multidisciplinary investigations at the Windover site'. In B. A. Purdy (ed.), *Wet site archaeology.* Caldwell, NJ: Telford.

————W. E. Ballinger, Jr., Agge, O. F., Laipis, P. J., and Hauswirth, W. W. (1986) 'Anatomical, cellular and molecular analysis of 8,000-yr-old human brain tissue from the Windover archaeological site'. *Nature* 323: 803–6.

Douglas, A. E. (1935) 'Dating Pueblo Bonito and other ruins of the South-west'. *National Geographical Society* 4: 1–74.

Dufour, D. (1990) 'Use of tropical rainforests by native Amazonians'. *BioScience* 40 (9): 652–59.

Dufraisse, A. (2006) 'Firewood economy during the 4th millennium bc at Lake Clairvaux, Jura, France'. *Environmental Archaeology* 11: 87–100.

——and Leuzinger, U. (2009) 'La Collecte du bois de feu dans le village néolithique d'Arbon-Bleiche 3 (lac de Constance, Suisse): Gestion du bois et déterminismes'. *Bulletin de la Société préhistorique française* 106 (4): 785–802.

——Pétrequin, A.-M., and Pétrequin, P. (2007) 'La Gestion du bois de feu: un indicateur des contextes socio-écologiques. Approche ethnoarchéologique dans les Hautes Terres de Papua (Nouvelle-Guinée indonésienne)'. In M. Besse (ed.),

Sociétés néolithiques: des faits archéologiques aux fonctionnements socio-économiques. Lausanne: Cahiers d'archéologie romande, 115–26.

DUISBERG, H. (ed.) (2008) *Living history in Freilichtmuseen. Neue Wege der Geschichtsvermittlung.* Ehestorf, Seevetal: WL-Druck.

DUNBAR, J. S., FAUGHT, M. K., and WEBB, S. D. (1988) 'Page-Ladson: an underwater Paleoindian site in northwestern Florida'. *The Florida Anthropologist* 41: 442–52.

DUNNING, N. P., LUZZADDER-BEACH, S., BEACH, T., JONES, J. G., SCARBOROUGH, V., and CULBERT, T. P. (2002) 'Arising from the *Bajos*: The evolution of a neotropical landscape and the rise of Maya civilization'. *Annals of the Association of American Geographer* 92 (2): 267–83.

DURHAM, W. H. (1992) 'Applications of evolutionary culture theory'. *Annual Review of Anthropology* 21: 331–55.

DWYER, P. (1990) *The pigs that ate the gardens: A human ecology from Papua New Guinea*. Ann Arbor: University of Michigan Press.

EARLE, T. (2002) *Bronze Age economics: The first political economies.* Denver: Westview.

EARWOOD, C. (1997) 'Bog butter: A two thousand year history'. *Journal of Irish Archaeology* 8: 25–42.

EBERSBACH, R. (2002) *Von Bauern und Rindern. Eine Ökosystemanalyse zur Bedeutung der Rinderhaltung in bäuerlichen Gesellschaften als Grundlage zur Modellbildung im Neolithikum.* Basel: Schwabe & Co.

——(2003) 'Paleoecological reconstruction and calculation on calorie requirements at Lake Zurich'. In J. Kunow and J. Müller (eds.), *Symposium Landschaftsarchäologie und geographische Informationssysteme. Archäoprognose Brandenburg I. Forschungen zur Archäologie im Land Brandenburg*: Wünsdorf: Fischer, 69–88.

——(2010*a*) 'Seeufersiedlungen und Architektursoziologie—ein Anwendungsversuch'. In P. Trebsche and N. Müller-Scheessel (eds.), *Der gebaute Raum. Bausteine einer Architektursoziologie vormoderner Gesellschaften*. Tübingen: Waxmann, 193–212.

——(2010*b*) 'Soziale Einheiten zwischen "Haus" und "Dorf"—neue Erkenntnisse aus den Seeufersiedlungen'. In E. Classen, T. Doppler, and B. Ramminger (eds.), *Familie—Verwandtschaft—Sozialstrukturen. Sozialarchäologische Forschungen zu neolithischen Befunden*. Kerpen-Loogh: Welt & Erde, 141–56.

EBERSCHWEILER, B. (1990*a*) 'Blockbauten im spätbronzezeitlichen Dorf von Greifensee-Böschen'. In Schweizerisches Landesmuseum (ed.), *Die ersten Bauern*. Zurich: Schweizerisches Landesmuseum, 193–200.

——(1990*b*) 'Die Türe von Robenhausen'. In Schweizerisches Landesmuseum (ed.), *Die ersten Bauern*. Zurich: Schweizerisches Landesmuseum, 191–2.

——(2004) *Bronzezeitliches Schwemmgut vom Chollerpark" in Steinhausen (Kanton Zug).* Basel: Schweizerische Gesellschaft für Ur- und Frühgeschichte.

EBERSCHWEILER, B. (2006) 'Destruction des palafittes dans les lacs zurichois: causes diverses, réponses adéquates'. In D. Ramseyer and M.-J. Roulière-Lambert (eds.), *Archéologie et érosion 2: Zones humides en péril*. Lons-le-Saunier: Centre Jurassien du Patrimoine, 73–9.

Eberschweiler, B., Hafner, A., and Wolf, C. (2006) 'Unterwasserarchäologie in der Schweiz. Bilanz und Perspektive aus den letzten 25 Jahren'. In A. Hafner, U. Niffeler, and U. Ruoff (eds.), *Die neue Sicht—Unterwasserarchäologie und Geschichtsbild*. Basel: Archäologie Schweiz, 24–46.

——Riethmann, P., and Ruoff, U. (2007) *Das spätbronzezeitliche Dorf von Greifensee-Böschen. Dorfgeschichte, Hausstrukturen und Fundmaterial.* Zurich: Kantonsarchäologie Zürich.

Edgeworth, M. (ed.) (2006) *Ethnographies of archaeological practice.* Oxford: Altamira.

Edson, S. (1979) 'Historical archaeology in the Waikato: An interim report on the Te Miro project'. *New Zealand Archaeological Association Newsletter* 22: 65–75.

Eggelsmann, R., Heathwaite, A. L., Grosse-Braukmann, G., Künstler, E., Naucke, W., Schuch, M., and Schweickle, V. (1993) 'Physical processes and properties of mires'. In A. L. Heathwaite and K. Göttlich (eds.), *Mires: Process, exploitation and conservation*. New York: John Wiley & Sons, 171–262.

Egloff, M. (1980) 'Les Gisements archéologiques neuchâtelois dans leur cadre géographique'. *Helvetia Archaeologica* 43/4: 84–91.

——(1981) 'Versunkene Dörfer der Urnenfelderzeit im Neuenburgen See: Forschung der Luftbildarchäologie'. *Archäologisches Korrespondenzblatt* 11: 55–63.

——(1987) '130 years of archaeological research in Lake Neuchâtel, Switzerland'. In J. M. Coles and A. J. Lawson (eds.), *European wetlands in prehistory*. Oxford: Clarendon, 23–32.

——(1988) 'Recent archaeological discoveries in Lake Neuchâtel, Switzerland: From the palaeolithic to the Middle Ages'. In B. Purdy (ed.), *Wet site archaeology*. Caldwell, NJ: Telford, 15–30.

——(1990) 'La rive nord du lac de Neuchâtel: du Magdalénien à l'Age du Bronze final'. In Schweizerisches Landesmuseum (ed.) *Die ersten Bauern*. Zurich: Schweizerisches Landesmuseum, 311–12.

Ekberg, G. (2003) 'Technology and archaeology'. In U. Djerw and J. Rönnby (eds.), *Treasures of the Baltic Sea: A hidden wealth of culture*. Stockholm: Swedish Maritime Museum, 42–52.

Elbaum, R., Melamed-Bessudo, C., Boaretto, E., Galili, E., Lev-Yadun, S., Levy, A. A., and Weiner, S. (2006) 'Ancient olive DNA in pits: preservation, amplification and sequence analysis'. *Journal of Archaeological Science* 33 (1): 217–26.

Elias, S. A. (2006) 'Quaternary beetle research: the state of the art'. *Quaternary Science Reviews* 25: 1731–7.

——(2010) 'The use of insect fossils in archaeology'. In S. A. Elias (ed.), *Advances in Quaternary Entomology. Developments in Quaternary Sciences 12*. Amsterdam: Elsevier, 89–123.

Ellen, R. (1982) *Environment, subsistence and system: The ecology of small-scale social formations.* Cambridge: Cambridge University Press.

Elston, R. G. (1986) 'Prehistory of the western area'. In W. D'Azevado (ed.), *Great Basin Handbook of North American Indians*. Washington, DC: Smithsonian, 135–48.

Engelbrecht, W. E. (1994) 'Palaeo-Indian watercraft: evidence and implications'. *North American Archaeologist* 15: 221–34.

Engen, M., and Spikins, P. (2007) '"A needle in a haystack?": Perspectives on prospection for submerged Mesolithic sites'. In C. Waddington and K. Pedersen (eds.), *Mesolithic studies in the North SeaBasin and beyond: Proceedings of a conference held at Newcastle in 2003*. Oxford: Oxbow, 25–32.

English Heritage (2002) 'English Heritage strategy for wetlands'. Online pdf: <http://www.english-heritage.org.uk/content/imported-docs/a-e/wetlandsstrategy.pdf>, accessed July 2011.

——(2008) *Conservation principles: Policies and guidance for the sustainable management of historic environment.* London: English Heritage.

Erickson, C. L. (1995) 'Archaeological Perspectives on Ancient Landscapes of the Llanos de Mojos in the Bolivian Amazon'. In P. Stahl (ed.), *Archaeology in the American Tropics: Current Analytical Methods and Applications.* Cambridge: Cambridge University Press, 66–95.

——(2000) 'The Lake Titicaca Basin: A PreColumbian Built Landscape'. In D. Lentz (ed.), *Imperfect Balance: Landscape Transformations in the PreColumbian Americas*. New York: Columbia University Press, 311–56.

——(2001) 'Pre-Columbian Fish Farming in the Amazon'. *Expedition* 43 (1): 7–8.

——(2006) 'The Domesticated Landscapes of the Bolivian Amazon'. In W. Balée and C. L. Erickson (eds.), *Time and Complexity in Historical Ecology: Studies in the Neotropical Lowlands*. New York: Columbia University Press, 235–78.

Evans, C. (1990) 'Review of B. A. Purdy [1988] Wet Site Archaeology [Telford Press]'. *Proceedings of the Prehistoric Society* 57: 339–40.

Eveleth, P. B., and Tanner, J. M. (1990) *Worldwide variation in human growth.* Cambridge: Cambridge University Press.

Fábián, S., and Serlegi, G. (2009) 'Settlement and environment in the Late Copper Age along the southern shore of Lake Belaton in Hungary'. In T. L. Thurston and R. B. Salisbury (eds.), *Reimagining regional analyses: The archaeology of spatial and social dynamics*. Cambridge: Cambridge Scholars, 199–233.

Fagan, B. M. (1991) *North America archaeology.* London: Thames & Hudson.

——(2000) *Ancient North America*. New York: Thames & Hudson.

——and van Noten, F. L. (1971) *The Hunter-Gatherers of Gwisho.* Tervuren: Musée Royal de l'Afrique Centrale.

Fang, J. (1991) 'Influence of sea level rise on the middle and lower reaches of the Yangtze river since 12,100 BP'. *Quaternary Science Reviews* 10: 527–36.

Fansa, M., and Schneider, R. (1990) 'Neue Erkenntnisse über den Bohlenweg XXV(Pr) und den Pfahlsteg XXX(Pr) zwischen Damme und Hunteburg'. *Archäologische Mitteilungen aus Nordwestdeutschland* 13: 17–26.

——(1993) 'Die Bohlenwege bei Ockenhausen/Oltmannsfehn, Gde. Uplengen, Ldkr. Leer'. *Archäologische Mitteilungen aus Nordwestdeutschland* 16: 23–43.

——(1995) 'Moorarchäologie in Stadt und Landkreis Oldenburg und der nahen Umgebung'. *Oldenburger Jahrbuch* 95: 235–70.

FEDICK, S. L. (ed.) (1996) *The managed mosaic: Ancient Maya agriculture and resource use.* Salt Lake City: University of Utah Press.

——(1998) 'Ancient Maya use of wetlands in Northern Quintana Roo, Mexico'. In K. Bernick (ed.), *Hidden dimensions: The cultural significance of wetland archaeology*. Vancouver: University of British Columbia Press, 107–29.

——and MORRISON, B. A. (2004) 'Ancient use and manipulation of landscape in the Yalahau region of the northern Maya lowlands'. *Agriculture and Human Values* 21 (2–3): 207–19.

FEDJE, D. W., MACKIE, A. P., WIGEN, R. J., MACKIE, Q., and LAKE, C. (2005) 'Kilgii Gwaay: An early maritime site in the South of Haida Gwaii'. In D. W. Fedje and R. W. Mathewes (eds.), *Haida Gwaii: Human history and environment from the time of the Loon to the time of the Iron People*. Vancouver: University of British Columbia Press, 187–203.

FELDTKELLER, A. (2004) 'Die Textilien von Seekirch-Achwiesen'. In Landesdenkmalamt Baden-Württemberg (ed.), *Ökonmischer und ökologischer Wandel am vorgeschichtlichen Federsee*. Freiburg: Janus, 56–70.

FENG, Z., THOMPSON, L. G., MOSLEY-THOMPSON, E., and YAO, T. (1993) 'Temporal and spatial variations of climate in China during the last 10,000 years'. *The Holocene* 3 (2): 174–80.

FIELD, J. (2006) 'Trampling through the Pleistocene: Does taphonomy matter at Cuddie Springs?' *Australian Archaeology* 63: 9–20.

——BARKER, J., BARKER, R., COFFEY, E., COFFEY, L., CRAWFORD, E., DARCY, L., FIELDS, T., LORD, G., STEADMAN, B., and COLLEY, S. (2000) 'Coming back: Aborigines and archaeologists at Cuddie Springs'. *Public Archaeology* 1 (1): 35–48.

FIELD, N., and PARKER PEARSON, M. P. (2003) *Fiskerton. An Iron Age timber causeway with Iron Age and Roman votive offerings: The 1981 excavations.* Oxford: Oxbow.

FINLAYSON, B. (1995) 'Complexity in the Mesolithic of the Western Scottish seaboard'. In A. Fischer (ed.), *Man and sea in the Mesolithic: Coastal settlement above and below present sea level.* Oxford: Oxbow, 261–4.

FISCHER, A. (ed.) (1995) *Man and the sea in the Mesolithic.* Oxford: Oxbow.

——(1999) 'Stone Age Åmose. Stored in museums and preserved in the living bog'. In B. J. Coles, J. M. Coles, and M. S. Jørgensen (eds.), *Bog bodies, sacred sites and wetland archaeology*. Exeter: Wetland Archaeology Research Project, 85–92.

——(2001) 'Scandinavia'. In B. J. Coles and A. Olivier (eds.), *The heritage management of wetlands in Europe*. Exeter: Europae Archaeologiae Consilium and WARP, 47–54.

——(2003) 'Trapping up the rivers and trading across the sea—steps towards the neolithisation of Denmark'. In L. Larsson, H. Kindgren, K. Knutsson, D. Loeffler, and A. Åkerlund (eds.), *Mesolithic on the move*. Oxford: Oxbow, 405–13.

——SCHLICHTHERLE, H., and PÉTREQUIN, P. (2004) 'Steps towards the heritage management of wetlands in Europe: response and reflection'. *Journal of Wetland Archaeology* 4: 199–206.

FISCHER, C. (1997) *Innovation und Tradition in der Mittel-und Spätbronzezeit: Gräber und Siedlungen in Neftenbach, Fällanden, Dietikon, Pfäffikon und Erlenbach.* Zurich: Kantonsarchäologie Zürich.

FISH, S. K., and KOWALEWSKI, S. A. (1990) *The archaeology of regions: A case for full-coverage survey.* Washington: Smithsonian.

FLAMMAN, J. P. (2004) 'Two burnt-down houses examined'. *EuroREA* 1: 93–102.

FLETCHER, R. (1984) 'Identifying spatial disorder: A case study of a Mongol fort'. In H. J. Hietala (ed.), *Intrasite spatial analysis in archaeology*. Cambridge: Cambridge University Press, 196–223.

——(1995) *The limits of settlement growth. A theoretical outline.* Cambridge: Cambridge University Press.

FLETCHER, W., and VAN DE NOORT, R. (2007) 'The lake-dwellings in Holderness, East Yorkshire, revisited: A journey into antiquarian and contemporary wetland archaeology'. In J. W. Barber, C. Clark, M. Cressey, A. Crone, A. Hale, J. C. Henderson, R. A. Housley, R. Sands, and A. Sheridan (eds.), *Archaeology from the wetlands: Recent perspectives*. Edinburgh: Society of Antiquaries of Scotland, 313–21.

FLOOD, J. (1990) *The riches of ancient Australia*. St Lucia: University of Queensland Press.

FOKKENS, H. (1999) 'Cattle and martiality: changing relations between man and landscape in the Late Neolithic and the Bronze Age'. In C. Fabech and J. Ringtved (eds.), *Settlement and Landscape*. Højbjerg: Jutland Archaeological Society, 35–43.

——and ARNOLDUSSEN, S. (2008) 'Towards new models'. In S. Arnoldussen and H. Fokkens (eds.), *Bronze Age settlements in the Low Countries*. Oxford: Oxbow, 1–16.

FORNI, G. (1997) 'Le Tecniche agricole nelle terramare'. In M. Bernabó Brea, A. Cardarelli, and M. Cremaschi (eds.), *Le terramare: La più antica civiltà padana*. Milan: Electa, 457–68.

FORS, Y., HELGE, E., and WICKHOLM, K. (2009) 'Ammonia treatment of acidic Vasa wood'. In K. Straetkvern and D. J. Huisman (eds.), *Proceedings of the 10th ICOM Group on Wet Organic Archaeological Materials Conference, Amsterdam 2007*. Amersfoort: ICOM Committee for Conservation Working Group on Wet Organic Archaeological Materials, 539–61.

FOSTER, R., and CROES, D. R. (2004) 'Joint tribal/college wet site investigations: A critical need for Native American expertise'. *Journal of Wetland Archaeology* 4: 125–37.

FRAKE, C. (1962) 'Cultural ecology and ethnography'. *American Anthropologist* 64 (1): 53–9.

FRANK, E. (1876) 'Die Pfahlbaustation Schussenried'. *Württemberg Naturwissenschaftliche Jahreshefte* 32: 1–8.

——(1892) 'Die Fundstellen bei Schussenried'. *Korrespondblatt der Deutschen Gesellschaft für Archäologie* 23: 108–21.

FRANKE, P. R., and WATSON, D. (1936) 'An experimental cornfield in Mesa Verde National Park; Symposium on prehistoric agriculture'. *University of New Mexico-Bulletin* 296: 35–41.

FRANKEL, D. (1991) *Remains to be seen: Archaeological insights into Australian Prehistory.* Melbourne: Longman Cheshire.

FRAZER, W. O., and TYRRELL, A. (eds.) (2000) *Social identity in Early Medieval Britain*. London: Leicester University Press.

FREDENGREN, C. (2002) 'Discovery programme in Lough Kinale'. *Archaeology Ireland* 16 (4): 20–3.

——(2004) 'The cutting edge'. *Archaeology Ireland* 18 (4): 28–31.

——(2007) 'The lake settlement project: from the deep waters'. *Antiquity* 81 (214): Project Gallery website <http://www.antiquity.ac.uk/projgall/fredengren314/>, accessed July 2011.

FREDERICK, C. (2007) 'Chinampas cultivation in the Basin of Mexico: Observations on the evolution of form and function'. In T. Thurston and C. Fisher (eds.), *Seeking a richer harvest: The archaeology of subsistence, intensification, innovation, and change*. New York: Springer, 107–24.

FREEMAN, C., OSTLE, N. J., FENNER, N., and KANG, H. (2004) 'A regulatory role for phenol oxidase during decomposition in peatlands'. *Soil Biology and Biochemistry* 36 (10): 1663–7.

FREI, K. M. (2009) 'News of the geographical origin of the Gerum cloak's raw material'. *Journal of Swedish Antiquarian Research* 104 (4): 313–15.

——BERGHE, I. V., FREI, R., MANNERING, U., and LYNGSTRøM, H. (2010) 'Removal of natural organic dyes from wool—implications for ancient textile provenance studies'. *Journal of Archaeological Science* 37 (9): 2136–45.

——SKALS, I., MANNERING, U., GLEBA, M., and LYNGSTRøM, H. (2009) 'The Huldremose Iron Age textiles, Denmark: An attempt to define their provenance applying the strontium isotope system'. *Journal of Archaeological Science* 36 (9): 1965–71.

FRENCH, C. (1988) 'Further aspects of the buried prehistoric soils in the fen margin northeast of Peterborough, Cambridgeshire'. In P. Murphy and C. French (eds.), *The exploitation of wetlands*. Oxford: BAReports British Series 186. Oxford: Archaeopress, 193–211.

——(2003) *Geoarchaeology in action: Studies in soil micromorphology and landscape evolution*. London: Routledge.

——and PRYOR, F. (1993) *The Southwest Fen Dyke Survey Project 1982–86*. East Anglian Archaeology Report 59. Peterborough: Fenland Archaeological Trust.

FRIEDRICH, M., REMMELS, S., KROMER, B., HOFMANN, J., SPURK, M., KAISER, K. F., ORCEL, C., and KÜPPERS, M. (2004) 'The 12,460-year Hohenheim Oak and pine tree-ring chronology from Central Europe—a unique annual record for radiocarbon calibration and paleoenvironmental reconstructions'. *Radiocarbon* 46 (3): 1111–22.

FRISANCHO, A. R. (1993) *Human adaptation and accommodation*. Ann Arbor: University of Michigan Press.

FUGAZZOLA DELPINO, M. A. (1995) *Un tuffo nel passato: 8000 anni fa nel lago di Bracciano*. Rome: Soprintendenza speciale at museo nazionale preistorico etnografico Luigi Pigorini.

——(1998) 'La vita quotidiana del Neolitico. Il sito della Marmotta sul lago di Bracciano'. In A. Pessina and G. Miscio (eds.), *Settemila anni fa il primo pane. Ambienti e culture delle prime comunità neolitiche. Catalogo della Mostra, Udine, Museo Friulano di Storia Naturale*. Udine: Museo Friulano di Storia Naturale, 192–211.

——and Mineo, M. (1995) 'La piroga neolitica del lago di Bracciano (La Marmotta 1)'. *Bullettino di Paletnologia Italiana* 86: 197–266.

——and Pessina, A. (1999) 'Le Village néolitique submergè de "La Marmotta"'. In J. Vaquer (ed.), *Le Néolitique du nord-ouest méditerranéen*. Joué-le-Tours: Congrès Préhistorique de France, 35–8.

Fukusawa, H., Koizumi, I., Okamura, M., and Yasuda, Y. (1994) 'Historical earthquake, flood and human activity events recorded in the Holocene sediments of Lake Suigetsu, Fukui Prefecture, central Japan'. *Journal of Geography* 103 (2): 127–39.

Fuller, D. Q., Qin, L., Zheng, Y. F., Zhao, Z. J., Hosoya, L. A., Chen, X. G., and Sun, G. P. (2009) 'The Domestication Process and Domestication Rate in Rice: Spikelet Bases from the Lower Yangtze'. *Science* 323: 1607–9.

Furey, L. (1996) 'Oruarangi: The archaology and material culture of a Hauraki pa'. *Bulletin of the Auckland Institute and Museum* 17.

Gackowski, J. (2000) 'On the dating and cultural aspects of the West Baltic Barrow Culture lake dwellings'. In Nicolaus Copernicus University (ed.), *Studies in the lake dwellings of the West Baltic Barrow Culture*. Toruń: Wydawnictwo Uniwersytetu Mikołaja Kopernika, 9–63.

Galili, E., Stanley, D. J., Sharvit, J., and Weinstein-Evron, M. (1997) 'Evidence for earliest olive-oil production in submerged settlements off the Carmel coast, Israel'. *Journal of Archaeological Science* 24: 1141–50.

——Weinstein-Evron, M., Hershkovitz, I., Gopher, A., Kislev, M., Lernau, O., Kolska-Horwitz, L., and Lernau, H. (1993) 'Atlil-Yam: A prehistoric site on the sea floor off the Israeli coast'. *Journal of Field Archaeology* 20: 133–57.

Galimberti, M., Bronk Ramsey, C., and Manning, S. W. (2004) 'Wiggle-match dating of tree-ring sequences'. *Radiocarbon* 46 (2): 917–24.

Gamble, C. (1993) *Timewalkers: The prehistory of global colonization.* Stroud: Alan Sutton.

Gao, M. H. (2005) *Archaeological geography in the lower regions of Yangtze River*. Fudan: University Press.

Gardner, G., and Stern, P. (1996) *Environmental problems and human behaviour.* New York: Allyn & Bacon.

Garrard, A., and Harvey, C. P. D. (1981) 'Environment and settlement during the Upper Pleistocene and Holocene at Jubba in the Great Nafud, Northern Arabia'. *Atlal* 5: 137–48.

Gassmann, P. (2007) 'L'Exploitation de quelques chênaies durante le Lüscherz et l'Auvernier-Cordé ancien: Quand les habitants du village littoral de Saint-Blaise/ Bains des Dames (Neuchâtel, Suisse) allaient aux bois'. In M. Besse (ed.), *Sociétés néolithiques: Des faits archéologiques aux fonctionnements socio-économiques*. Lausanne: Cahiers d'archéologie romande, 101–14.

Gaughwin, D., and Sullivan, H. (1984) 'Aboriginal boundaries and movements in Western Port, Victoria'. *Aboriginal History* 8 (1/2): 80–98.

Gearey, B. R., Marshall, P., and Hamilton, D. (2009) 'Correlating archaeological and palaeoenvironmental records using a Bayesian approach: a case study from Sutton Common, South Yorkshire, England'. *Journal of Archaeological Science* 36: 1477–87.

Gebühr, M., and Eisenbeiss, S. (2007) 'Moorleichen—Funde, Deutung und Bedeutung'. In A. Wieczorek, W. Rosendahl, and M. Tellenbach (eds.), *Mumien: Der Traum vom ewigen Leben*. Mainz: Philipp von Zabern, 53–68.

Gehlen, B. (2007) 'Typo-chronological aspects of the microliths from Friesack 4 (Brandenburg, Germany). First results.' *Mesolithic Miscellany* 18 (2): 18–22.

Gell, A. (1998) *Art and Agency.* Oxford: Clarendon.

Gerritsen, F. A. (1999*a*) 'The cultural biography of Iron Age houses and the long-term transformation of settlement patterns in the southern Netherlands'. In C. Fabech and J. Ringtved (eds.), *Settlement and landscape. Proceedings of a conference in Aarhus, Denmark, May 4–7, 1998*. Højbjerg: Aarhus University Press, 139–48.

——(1999*b*) 'To build and abandon. The cultural biography of late prehistoric houses and farmsteads in the southern Netherlands'. *Archaeological Dialogues* 6 (2): 78–97.

——(2003) *Local identities. Landscape and community in the late prehistoric Meuse-Demer-Scheldt region.* Amsterdam: Amsterdam University Press.

——(2004) 'Archaeological perspectives on communities'. In J. Bintliff (ed.), *A companion to archaeology*. Oxford: Blackwell, 141–54.

——(2007) 'Relocating the house: Social transformations in Late Prehistoric Northern Europe'. In R. A. Beck (ed.), *The durable house. House society models in archaeology*. Carbondale: Center for Archaeological Investigations, 154–74.

——(2008) 'Domestic times: Houses and temporalities in Late Prehistoric Europe'. In A. Jones (ed.), *Prehistoric Europe: Theory and practice*. Oxford: Wiley-Blackwell, 143–61.

Gey, I. A. (1986) 'The study of the ceramics methods of the Tripolye settlement Stariye Kukoneshty'. *Reports of the Instituteof Archaeology of the USSR Academy of Sciences Moscow* 185: 22–6.

Giachi, G., Secci, M. M., Pignatelli, O., Gambogi, P., and Lippi, M. M. (2010) 'The prehistoric pile-dwelling settlement of Stagno (Leghorn, Italy): Wood and food resource exploitation'. *Journal of Archaeological Science* 38: 1–9.

Gifford, E., and Gifford, J. (2004) 'The use of half-scale model ships in archaeological research with particular reference to the Graveney, Sutton Hoo and Ferriby ships'. In P. Clark (ed.), *The Dover Bronze Age boat in context: Society and water transport in prehistoric Europe*. Oxford: Oxbow, 67–81.

Gilbert, M. T. P., Bandelt, H.-J., Hofreiter, M., and Barnes, I. (2005) 'Assessing ancient DNA studies'. *Trends in Ecology and Evolution* 20: 541–4.

——Tomsho, L. P., Rendulic, S., Packard, M., Drautz, D. I., Sher, A., Tikhonov, A., Dalén, L., Kuznetsova, T., Kosintsev, P., Campos, P. F., Higham, T. F. G., Collins, M. J., Wilson, A. S., Shidlovskiy, F., Buigues, B., Ericson, P. G. P., Germonpré, M., Götherström, A., Iacumin, P., Nikolaev, V., Nowak-Kemp, M., Willerslev, E., Knight, J. R., Irzyk, G. P., Perbost, C. S., Fredrikson, K. M., Harkins, T. T., Sheridan, S., Miller, W. and Schuster, S. C. (2007) 'Whole-genome shotgun sequencing of mitochondria from ancient hair shafts'. *Science* 317: 1927–30.

Gillieson, G., Gorecki, P. P., and Hope, G. S. (1985) 'Prehistoric agricultural systems in a lowland swamp, Papua New Guinea'. *Archaeology in Oceania* 20: 32–7.

Gilliland, M. S. (1989) *Key Marco's buried treasure.* Gainesville: University of Florida Press.

Gilman, P. J. (1998) 'Essex fish traps and fisheries: An integrated approach to survey, recording, and management'. In K. Bernick (ed.), *Hidden dimensions: The cultural significance of wetland archaeology*. Vancouver: University of British Columbia Press, 273–89.

Giorgi, R., Chelazzi, D., and Baglioni, P. (2006) 'Conservation of acid waterlogged shipwrecks: Nanotechnologies for de-acidification'. *Applied Physics A* 83 (4): 567–71.

Girininkas, A. (1980) 'Kretuonas: Vidurinis ir v lyvasis neolitas'. *Lietuvos archeologija* 7: 8–18.

Girling, M. A. (1979) 'Fossil insects from the Sweet Track'. *Somerset Levels Papers* 5: 84–93.

——(1982) 'The effect of the Meare Heath flooding episodes on the Coleopteran succession'. *Somerset Levels Papers* 8: 46–50.

——(1984) 'Investigations of a second insect assemblage from the Sweet Track'. *Somerset Levels Papers* 10: 79–91.

Glaser, R., Brazdil, R., Pfister, C., Dobrovolny, P., Barriendos Valve, M., Bokwa, A., Camuffo, D., Kotyza, O., Limanowka, D., Racz, L., and Rodrigo, F. S. (1999) 'Seasonal temperature and precipitation fluctuations in selected parts of Europe during the sixteenth century'. *Climate Change* 43: 169–200.

Glastrup, J., Shashoua, Y., Egsgaard, H., and Mortensen, M. N. (2006) 'Degradation of PEG in the warship Vasa'. *Macromolecular Symposia* 238 (1): 22–9.

Glaz, P. N., Nozais, C., and Arseneault, D. (2009) 'Macroinvertebrates on coarse woody debris in the littoral zone of a boreal lake'. *Marine and Freshwater Research* 60: 960–70.

Gleeson, P., and Grosso, G. (1976) 'Ozette site'. In D. R. Croes (ed.), *The excavation of water-saturated archaeological sites (wet sites) on the Northwest Coast of North America*. Ottawa: National Museum of Man Mercury Series, 13–44.

Gliessman, S. R., Turner II, B. L., May, F. J. R., and Amador, M. F. (1983) 'Ancient raised field agriculture in the Maya Lowlands of Southeastern Mexico'. In J. P. Darch (ed.), *Drained field agriculture in Central and South America*. BAR International Series 189. Oxford: Archaeopress.

Glob, B. V. (1969) *The bog people: Iron Age man preserved.* London: Faber & Faber.

Glover, E. (1998) 'Mangroves, molluscs and man. Archaeological evidence for biogeographical changes in mangrove around the Arabian Peninsula'. In C. S. Phillips, D. T. Potts, and S. Searight (eds.), *Arabia and its neighbours. Essays on prehistorical and historical developments*. Leuven: Brepols, 63–78.

Gnepf, U., Moser, P., and Weiss, J. (1996) 'Morastige Wege und stattliche Häuser im mittelbronzezeitlichen Cham'. *Archäologie Schweiz* 19: 64–7.

Godwin, H. (1978) *Fenland: Its ancient past and uncertain future.* Cambridge: Cambridge University Press.

Goldberg, P., and Berna, F. (2010) 'Micromorphology and context'. *Quaternary International* 214: 56–62.

——and Macphail, R. I. (2006) *Practical and theoretical geoarchaeology.* Oxford: Blackwell.

Golley, F. (1992) *The ecosystem concept in biology.* New Heaven: Yale University Press.

Gollnisch, H., and Seifert, M. (1998) 'Gebäude in der Zentral- und Ostschweiz'. In Schweizerische Gesellschaft für Ur- und Frühgeschichte (ed.), *Die Schweiz vom*

Paläolithikum bis zum frühen Mittelalter: SPM Bronzezeit. Basel: Schweizerische Gesellschaft für Ur- und Frühgeschichte, 198–205.

GOLLNISCH-MOOS, H. (1999) *Ürschhausen-Horn: Haus- und Siedlungsstrukturen der spätestbronzezeitlichen Siedlung.* Frauenfeld: Departement für Erziehung und Kultur des Kantons Thurgau.

GOLSON, J. (1959) 'Culture change in prehistoric New Zealand'. In J. D. Freeman and W. R. Geddes (eds.), *Anthropology in the South Seas.* New Plymouth: Thomas Avery, 29–74.

——(1977) 'No room at the top: Agricultural intensification in the New Guinea Highlands'. In J. Allen, J. Golson, and R. Jones (eds.), *Sunda and Sahul: Prehistoric studies in Southeast Asia, Melanesia and Australia*. London: Academic Press, 601–38.

——(1982) 'The Ipomoean Revolution revisited: Society and the sweet potato in the upper Waghi valley'. In A. Strathern (ed.), *Inequality in New Guinea Highlands societies*. Cambridge: Cambridge University Press, 109–36.

——(1989) 'The origins and development of New Guinea agriculture'. In D. R. Harris and G. C. Hillman (eds.), *Foraging and farming: The evolution of plant exploitation*. London: Unwin Hyman, 678–87.

——(1990) 'Kuk and the development of agriculture in New Guinea: Retrospection and introspection'. In D. E. Yen and J. M. J. Mummery (eds.), *Pacific production systems. Approaches to economic prehistory*. Canberra: Australian National University, 139–47.

——and GARDNER, D. S. (1990) 'Agriculture and sociopolitical organisation in New Guinea Highlands prehistory'. *Annual Review of Anthropology* 19: 395–417.

——and STEENSBERG, A. (1985) 'The tools of agricultural intensification in the New Guinea Highlands'. In I. S. Farrington (ed.), *Prehistoric intensive agriculture in the Tropics*. Oxford: BAR International Series 232. Oxford: Archaeopress, 321–45.

GOODMAN, S. (1985) 'Material culture: basketry and fiber artifacts'. In D. H. Thomas (ed.), *The archaeology of Hidden Cave, Nevada*. New York: American Museum of Natural History, 262–98.

GOPAL, B. (2009) 'Biodiversity in wetlands'. In E. Maltby and T. Barker (eds.) *The wetlands handbook*: 65–95. Oxford: Blackwell.

GÖRANSSON, H. (1995) *Alvastra pile dwelling. Palaeoethnobotanical studies.* Lund: Lund University Press.

GORECKI, P. P. (1985) 'The conquest of a new "wet and dry" territory: Its mechanisms and its archaeological consequence'. In I. S. Farrington (ed.), *Prehistoric intensive agriculture in the tropics.* BAR International Series 232. Oxford: Archaeopress, 321–45.

——(1986) 'Human occupation and agricultural development in the Papua New Guinea Highlands'. *Mountain Research and Development* 6: 159–66.

GÖRLITZ, D. (2008) 'Reed boat expedition ABORA III—Stormy voyage across the North Atlantic'. In M. J. Springmann and H. Wernicke (eds.), *Historical boat and ship replicas*. Friedland: Steffen, 45–56.

——(2010) 'Experimentelle Archäologie und das Meer'. *Plattform* 17–18: 45–51.

GOSDEN, C. (1994) *Time and social being.* London: Routledge.

——and MARSHALL, Y. (1999) 'The cultural biography of objects'. *World Archaeology* 31 (2): 169–78.

Goslar, T., Pazdur, A., Pazdur, M. F., and Walanus, A. (1989) 'Radiocarbon and varve chronologies of annual laminated Lake sediment of Gosciaz Lake, Central Poland'. *Radiocarbon* 31: 940–7.

Gostnell, C. (2005) 'Efficacy of an interferometric sonar for hydrographic surveying: Do interferometers warrant an in-depth examination?' *The Hydrographic Journal* 118: 17–24.

Gramsch, B. (1989) 'Excavations near Friesack: An Early Mesolithic marshland site in the northern plain of Central Europe'. In C. Bonsall (ed.), *The Mesolithic in Europe*. Edinburgh: John Donald, 313–24.

——(1991) 'Ausgrabungen auf einem weiteren frühmesolithischen Fundplatz bei Friesack, Kr. Nauen'. *Ausgrabungen und Funde* 36: 51–6.

——(1992) 'Friesack mesolithic wetlands'. In B. J. Coles (ed.), *The Wetland Revolution in Prehistory*. Exeter: Prehistoric Society, 65–72.

——(2000) 'Friesack: Letzte Jäger und Sammler in Brandenburg'. *Jahrbuch des Römisch-Germanisches Zentralmuseum Mainz* 47: 51–96.

Grattan, D. W. (1982) 'A practical comparative study of several treatments for waterlogged wood'. *Studies in Conservation* 27: 124-36.

——Bilz, M., Grant, T., and Logan, J. (2006) 'Outcome determines treatment—an approach to the treatment of waterlogged wood'. *Journal of Wetland Archaeology* 6: 49–63.

Greenwood, M. T., Wood, P. J., and Monk, M. A. (2006) 'The use of fossil caddisfly fauna assemblages in the reconstruction of flow environments from floodplain paleochannels of the River Trent, England'. *Journal of Paleolimnology* 35: 747–61.

Greer, S., Harrison, R., and McIntyre-Tamwoy, S. (2002) 'Community-based archaeology in Australia'. *World Archaeology* 34 (2): 265–87.

Gregory, D., and Jensen, P. (2006) 'The importance of analysing waterlogged wooden artefacts and environmental conditions when considering their *in situ* preservation'. *Journal of Wetland Archaeology* 6: 65–81.

Groenman-van Waateringe, W., Kilian, M., and Londen, H. van (1999) 'The curing of hides and skins in European prehistory'. *Antiquity* 73: 884–90.

Gronenborn, D. (1998) 'Ältestbandkeramische Kultur, 1a Hoguette, Limburg and . . . what else?—Contemplating the Mesolithic–Neolithic transition in southern Central Europe'. *Documenta Praehistorica* 25: 189–202.

——(1999) 'A variation on a basic theme: the transition to farming in southern central Europe'. *Journal of World Prehistory* 13 (2): 123–210.

Gronendijk, H. (2003) 'New archaeological issues in the former Bourtanger Moor (the Netherlands)'. In A. Bauerochse and H. Haßmann (eds.), *Peatlands: Archaeological sites—archives of nature—nature conservation—wise use*. Rahden: Marie Leidorf, 36–47.

Gross, E. (1987) 'Die Lage des Grabungsplatzes'. In Berichte der Zürcher Denkmalpflege (ed.), *Zürich "Mozartstrasse": Neolithische und bronzezeitliche Ufersiedlungen*. Zurich: Orell Füssli, 13–18.

Gross-klee, E. (1997) 'Einladung'. In J. Schibler, H. Hüster-Plogmann, S. Jacomet, C. Brombacher, E. Gross-Klee, and A. Rast-Eicher (eds.), *Ökonomie und Ökologie neolithischer und bronzezeitlicher Ufersiedlungen am Zürichsee*. Zurich: Zürich und Egg, 13–39.

Gross-klee, E. Hochuli, S., Auf der Mauer, R., Nüssli Baltensweiler, S., Reusser, E., Schoch, W. H., Sormaz, T., Jacomet, S., Martinoli, D., Pegurri, G., and Weiss, J. (2002) 'Die jungsteinzeitliche Doppelaxt von Cham-Eslen. Gesamtbericht über einen einzigartigen Fund aus dem Zugersee'. *Tugium* 18: 69–101.

Gumbley, W., Johns, D., and Law, G. (2005) *Management of wetland archaeological sites in New Zealand.* Wellington: Department of Conservation.

Gumiński, W. (1998) 'The peat-bog site Dudka, Masurian Lakeland: An example of conservative economy'. In M. Zvelebil, L. Domańska, and R. Dennell (eds.), *Harvesting the sea, farming the forest: The emergence of Neolithic societies in the Baltic Region*. Sheffield: Sheffield Academic Press, 103–9.

——and Michniewicz, M. (2003) 'Forest and mobility. A case from the Fishing Camp Site Dudka, Masuria, north-eastern Poland'. In L. Larsson, H. Kindgren, K. Knutsson, D. Loeffler, and A. Åkerlund (eds.), *Mesolithic on the move*. Oxford: Oxbow, 119–27.

Gustafson, C. E., Gilbow, D., and Daugherty, R. D. (1979) 'The Manis Mastodon Site: Early man on the Olympic Peninsula'. *Canadian Journal of Archaeology* 3: 157–64.

Haarnagel, W. (1977) 'Das eisenzeitliche Dorf "Feddersen Wierde", seine siedlungsgeschichtliche Entwicklung, seine wirtschaftliche Funktion und die Wandlung seiner Sozialstruktur'. In H. Jankuhn, R. Schützeichel, and F. Schwind (eds.), *Das Dorf der Eisenzeit und des frühen Mittelalters*. Göttingen: Vandenhoeck & Ruprecht, 253–84.

Haas, J. N., and Magny, M. (2004) 'Schichtgenese und Vegetationsgeschichte'. In S. Jacomet, U. Leuzinger, and J. Schibler (eds.), *Die jungsteinzeitliche Seeufersiedlung Arbon-Bleiche 3*. Frauenfeld: Veröffentlichung des Amtes für Archäologie des Kantons Thurgau, 43–9.

Haberle, S. G., Hope, G. S., and De Fretes, Y. (1991) 'Environmental change in the Baliem valley, montane Irian Jaya, Republic of Indonesia'. *Journal of Biogeography* 18: 25–40.

Hafner, A. (1992) *Lattrigen VI-Riedstation: Siedlungsplan und Baugeschichte.* Berne: Haupt.

——(1996) 'Aspekte der Siedlungsarchäologie des Jung- und Spätneolithikums am Bielersee'. In H.-J. Beier (ed.), *Studien zum Siedlungswesen im Jungneolithikum*. Archäologische Fachliteratur. Weissbach: Beier & Beran., 3–21.

——(2001) 'Archäologie unter Wasser. Sondierungen und Rettungsgrabungen 1998/99 im Bielersee bei Biel-Vingelz und Nidau'. *Bieler Jahrbuch* 2000: 37–49.

——(2004) 'Underwater archaeology: Lake-dwellings below the water surface'. In F. Menotti (ed.), *Living on the lake in prehistoric Europe: 150 years of lake-dwelling research*. London: Routledge, 178–93.

——(2005) 'Neolithische und bronzezeitliche Seeufersiedlungen am Bielersee. Neue Ansätze für Forschung und Erhaltung'. In P. Della Casa and M. Trachsel (eds.), *WES'04: Wetland economies and societies*. Zurich: Chronos, 267–76.

——(2006) 'Mesures de protection pour la sauvegarde des sites archéologiques du Lac de Bienne'. In D. Ramseyer and M.-J. Roulière-Lambert (eds.), *Archéologie et érosion—2: Zones humides en péril.* Lons-le-Saunier: Centre Jurassien du Patrimoine, 33–7.

——and SUTER, P. J. (2000) *-3400: die Entwicklung der Bauerngesellschaften im 4. Jahrtausend v. Chr. am Bielersee.* Berne: Berner Lehrmittel- und Medienverlag.

——(2004) *Aufgetaucht 1984–2004.* Berne: Archäologischer Dienst des Kantons Bern.

——and WOLF, C. (1997) 'Pfahlbauten der Westschweiz—Die Seeufersiedlungen zwischen Bielersee und Lac Léman'. In H. Schlichtherle (ed.), *Pfahlbauten rund um die Alpen*. Stuttgart: Konrad Theiss, 50–5.

——NIFFELER, U., and RUOFF, U. (eds.) (2006) *Die neue Sicht.* Basel: Archäologie Schweiz.

HAGBERG, U. E. (1967) *The archaeology of Skedemosse I–II.* Stockholm: Almqvist & Wiksell.

——(1988) 'The Bronze Shields from Fröslunda near Lake Vänern, West Sweden'. In B. Hårdh, L. Larsson, D. Olausson, and R. Petré (eds.), *Trade and exchange in prehistory*. Stockholm: Almquist & Wiksell, 119–26.

HAJDAS, I., and BONANI, G. (2000) 'Radiocarbon dating of varve chronologies: Soppensee and Holzmaar Lakes after ten years'. *Radiocarbon* 42: 349–53.

————and GOSLAR, T. (1995*a*) 'Radiocarbon dating the Holocene in the Gosciaz Lake floating varve chronology'. *Radiocarbon* 37: 71–4.

——IVY, S. D., BEER, J., BONANI, G., IMBODEN, D., LOTTER, A. F., STURM, M., and SUTER, M. (1993) 'AMS radiocarbon dating and varve chronology of Lake Soppersee: 6000-12000 ^{14}C years BP'. *Climate Dynamics* 9: 107–16.

——ZOLITSCHKA, B., IVY-OCHS, S. D., BEER, J., BONANI, G., LEROY, S. A. G., NEGENDANK, J. W., RAMRATH, M. and SUTER, M. (1995*b*) 'AMS radiocarbon dating for annually laminated sediments from Lake Holzmaar, Germany'. *Quaternary Science Reviews* 14: 137–43.

HALE, S. H. (1984) 'Prehistoric environmental exploitation around Lake Okeechobee'. *Southeastern Archaeology* 3: 187.

HALL, D. N., and COLES, J. M. (1994*a*) *Fenland Survey: An essay in landscape and persistence.* London: English Heritage.

——(1994*b*) *Fenland Survey: An essay in landscape and persistence.* London: English Heritage.

HAMILTON, F. E. (1999) 'Southeastern Archaic mounds: Examples of elaboration in a temporally fluctuating environment?' *Journal of Anthropological Archaeology* 18: 344–55.

HAMMARLUND, D., BJÖRCK, S., BUCHARD, B., ISRAELSON, C., and THOMSEN, T. (2003) 'Rapid hydrological changes during the Holocene revealed by stable isotope records of lacustrine carbonates from Lake Igelsjön, southern Sweden'. *Quaternary Science Reviews* 22: 353–70.

HAMMOND, R. F. (1981) *The peatlands of Ireland.* Dublin: An Foras Talúntais.

HANECA, K., BOEREN, I., VAN ACKER, J., and BEECKMANN, H. (2006) 'Dendrochronology in suboptimal conditions: Tree rings from medieval oak from Flanders (Belgium) as dating tools and archives of past forest management'. *Vegetation History and Archaeobotany* 15 (2): 137–44.

HANSEN, H. O. (1961) 'Undommelige Oldtidhuse'. *Kuml* 1961: 128–45.

——(1962) *I built a Stone Age house.* London: Phoenix.

——(1966) *Bognaeseksperiment.* Lejre: Lejre Centre.

——(1969) 'Experimental ploughing with a Dostrop ard replica'. *Tools and Tillage* 1 (2): 67–92.

Hansen, H. O. (1977) *The prehistoric village at Lejre.* Lejre: Historical-Archaeological Research Centre.

Harding, D. W. (2004) *The Iron Age in northern Britain: Celts and Romans, natives and invaders.* London: Routledge.

——(2007) 'Crannogs and island duns: an aerial perspective'. In J. W. Barber, C. Clark, M. Cressey, A. Crone, A. Hale, J. C. Henderson, R. A. Housley, R. Sands, and A. Sheridan (eds.), *Archaeology from the wetlands: Recent perspectives.* Edinburgh: Society of Antiquaries of Scotland, 267–73.

Harriot, T. (1588) *A brief and true report of the New Found Land of Virginia.* London.

Harris, M. (1998) 'The rhythm of life: seasonality and sociality in a riverine village'. *Journal of the Royal Anthropological Institute* 4 (1): 65–82.

——(2000) *Life on the Amazon: The Anthropology of a Brazilian Peasant Village.* Oxford: Oxford University Press.

——(2005) 'Riding a wave: Embodied skills and colonial history on the floodplain of the Amazon'. *Ethnos* 70 (2): 197–219.

Harris, S. (2008) 'Exploring the materiality of prehistoric cloth-types'. In P. Cunningham, J. Heeb, and R. Paardekooper (eds.), *Experiencing archaeology by experiment*. Oxford: Oxbow, 81–102.

Harrison, G. A., and Morphy, H. (eds.) (1998) *Human adaptation.* New York: Berg.

Harrison, R. (2004) *Shared landscapes: Archaeologies of attachment and pastoral industry in New South Wales*. Sydney: University of New South Wales Press.

Hartz, S., and Lübke, H. (1995) 'Tauchprospektion in der Hohwachter Bucht—Zur Frage der Erhaltung submariner steinzeitlicher Küstenwohnplätze in der westlichen Ostsee'. In Landesdenkmalamt Baden-Württemberg (ed.), *Archäologie unter Wasser1*. Stuttgart: Landesdenkmalamt Baden-Württemberg, 116–24.

————(2004) 'Zur chronostratigraphischen Gliederung der Erteb⌀lle Kultur und frühesten Trichterbecherkultur in der südlichen Mecklenburger Bucht'. *Bodendenkmalpflege in Mecklenburg-Vorpommern* 52: 119–43.

————(2006) 'New evidence for a chronostratigraphic division of the Erteb⌀lle Culture and the earliest Funnel Beaker Culture on the Southern Mecklenburg Bay'. In C.-J. Kind (ed.), *After the Ice Age: Settlements, subsistence and social development in the Mesolithic of Central Europe*. Stuttgart: Proceedings of the Rottenburg International Conference, 59–74.

Harwath, A. (1995) 'Erfahrungen mit der Einrichtung von Caisson- und Dammbauten in der Ufersiedlung Hornstaad am Bodensee'. In Landesdenkmalamt Baden-Württemberg (ed.) *Archäologie unter Wasser 1.* Stuttgart: Landesdenkmalamt Baden-Württemberg, 155–62.

Hastings, M. (1998) 'The brain, circadian rhythms and clock genes'. *British Medical Journal* 317: 1704–7.

Haubrichs, R. (2005) 'L'Etude de la pourpre: histoire d'une couleur, chimie et expérimentations'. *Preistoria Alpina* 40 (Suppl. 1): 133–60.

Hayen, H. (1957) 'Zur Bautechnik und Typologie der vorgeschichtlichen, frühgeschichtlichen und mittelalterlichen hölzernen Moorwege und Moorstrassen'. *Oldenburger Jahrbuch* 56 (2): 83–189.

——(1971) 'Hölzerne Kultfiguren am Bohlenweg XLII(Ip) im Wittemoor'. *Die Kunde* 21: 1–36.

——(1984) 'Moorarchäologie in Niedersachsen'. *Berichte zur Denkmalpflege in Niedersachsen* 4: 132–5.

HEAD, L. (1990) 'Review of 'complex hunter-gatherers' by Elisabeth Williams'. *Archaeology in Oceania* 25 (2): 84–5.

HECKENBERGER, M., and NEVES, E. G. (2009) 'Amazonian archaeology'. *Annual Review of Anthropology* 38: 251–66.

HEDEAGER, L. (1999) 'Sacred topography. Deposition of wealth in the cultural landscape'. In A. Gustafson and H. Karlsson (eds.), *Glyfer och arkeologiska rum—en vänbok till Jarl Nordblad*. Göteborg: Department of Archaeology, 229–52.

HEIDER, K. G. (1970) *The Dugum Dani: A Papuan culture in the Highlands of West New Guinea*. New York: Wenner-Gren Foundation.

HEIRI, O., and MILLET, L. (2005) 'Reconstruction of Late Glacial summer temperatures from chironomoid assemblages in Lac Lautrey (Jura, France)'. *Journal of Paleolimnology* 20: 1–12.

HEIZER, R. F., and NAPTON, L. K. (1970) 'Archaeology as seen from Lovelock Cave, Nevada'. *University of CaliforniaArchaeological Research Facility Contributions* 10 (1).

HELBLING-GLOOR, B. (2004) 'Die Pfahlbauer in Schulbuch und Jugendliteratur'. In Antiquarische Gesellschaft in Zürich (ed.), *Pfahlbaufieber: Von Antiquaren, Pfahlbaufischern, Altertümerhändlern und Pfahlbaumythen*. Zurich: Chronos, 187–201.

HENCKEN, H. O. (1936) 'Ballinderry crannóg no. 1'. *Proceedings of the Royal Irish Academy* 43 (5): 103–239.

——(1950) 'Lagore crannóg: An Irish royal residence of the seventh to tenth century AD'. *Proceedings of the Royal Irish Academy* 53 (1): 1–248.

HENDERSON, J. C. (1998*a*) 'Islets through time: The definition, dating and distribution of Scottish crannogs'. *Oxford Journal of Archaeology* 17 (2): 227–44.

——(1998*b*) 'A survey of crannogs in the Lake of Menteith, Stirlingshire, Scotland'. *Proceedings of the Society of Antiquaries of Scotland* 128: 273–92.

——(2004) 'The Scottish wetland archaeology programme: Assessing and monitoring the resource'. *Journal of Wetland Archaeology* 4: 169–82.

——(2007*a*) 'Recognizing complexity and realizing the potential of Scottish crannogs'. In J. W. Barber, C. Clark, M. Cressey, A. Crone, A. Hale, J. C. Henderson, R. A. Housley, R. Sands, and A. Sheridan (eds.), *Archaeology from the wetlands: Recent perspectives*. Edinburgh: Society of Antiquaries of Scotland, 231–41.

——(2007*b*) 'Resisting decay, wind and waves: New research on the lake-dwellings of South-West Scotland'. In J. W. Barber, C. Clark, M. Cressey, A. Crone, A. Hale, J. C. Henderson, R. A. Housley, R. Sands, and A. Sheridan (eds.), *Archaeology from the wetlands: Recent perspectives*. Edinburgh: Society of Antiquaries of Scotland, 289–302.

——(2009) 'Taking the waters: Scottish crannogs and the Atlantic Iron Age'. In G. Cooney, K. Becker, J. Coles, M. Ryan, and S. Sievers (eds.), *Relics of old decency: Archaeological studies in later prehistory (Festschrift for Barry Raftery)*. Dublin: Worldwell Books, 39–48.

——CRONE, B. A., and CAVERS, M. G. (2003) 'A condition survey of selected crannogs in south-west Scotland'. *Transactions Dumfriesshire and Galloway Natural History and Antiquarian Society* 77: 79–102.

Heussner, K.-U. (2008) 'Cronologia assoluta della tarda Eta' del Bronzo e della prima Eta' del Ferro a Longola/Poggiomarino'. In P. G. Guzzo and M. P. Guidobaldi (eds.), *Nuove ricerche archeologiche nell'area vesuviana (scavi 2003–2006).* Rome: L'erma di Bretschneider, 489–91.

Heydeck, J. (1889) 'Die Pfahlbauten im Szonsta—und Tulewo-See'. *Sitzungsberichte der Altertumsgesellschaft Prussia* 14: 127–37.

——(1909) 'Pfahlbauten in Ostpreußen'. *Sitzungsberichte der Altertumsgesellschaft Prussia* 22: 194–202.

Heyerdahl, T. (1950) *The Kon-Tiki expedition. By raft across the South Seas*. London: Allen & Unwin.

Hicks, S., and Hyvärinen, H. (1997) 'The vegetation history of northern Finland'. *Helsinki Papers in Archaeology* 10: 25–34.

Hirsch, K., Klooß, S., and Klooß, R. (2007) 'Der endmesolithisch-neolithische Küstensiedlungsplatz bei Baabe im Südosten der Insel Rügen'. *Bodendenkmalpflege in Mecklenburg-Vorpommern Jahrbuch* 55: 11–51.

Hiscock, P. (1996) 'Mobility and technology in the Kakadu coastal wetlands'. *Bulletin of the Indo-Pacific Prehistory Association* 15: 151–7.

——(2008) *Archaoeology of Ancient Australia*. London: Routledge.

Hitchcock, G. (1996) 'A note on the abandonment of raised field agricultural systems in the lower Bensbach River area, southwest Papua New Guinea'. *Australian Archaeology* 43: 37–8.

Hochuli, S. (2002) 'Teil eines neolithischen Schuhs aus Zug. Mit einem Beitrag von Anne Reichert: Weich und warm auf Moossohlen. Experimente zur 'Rheumasohle' von Zug'. *Jahrbuch der Schweizerischen Gesellschaft für Ur- und Frühgeschichte* 85: 45–54.

——and Röder, B. (2001) 'Bronzezeitliches Strandgut mit rätselhaften Holzobjekten aus Steinhausen ZG'. *Archäologie Schweiz* 24 (1): 2–13.

——and Schaeren, G. F. (2006) 'Suivi du niveau de la nappe phréatique dans les palafittes du canton de Zoug'. In D. Ramseyer and M.-J. Roulière-Lambert (eds.), *Archéologie et érosion—2: Zones humides en péril.* Lons-le-Saunier: Centre Jurassien du Patrimoine, 57–61.

Hodder, I. (ed.) (1982) *Symbolic and Structural Archaeology.* Cambridge: Cambridge University Press.

——(1990) *The domestication of Europe*. Oxford: Blackwell.

——(2001) 'Symbolism and the origins of agriculture in the Near East'. *Cambridge Archaeological Journal* 11 (1): 107–12.

——(2006) *Çatal Höyük, The Leopard's Tale: Revealing the mysteries of Turkey's ancient 'town'.* London: Thames & Hudson.

——and Preucel, R. W. (eds.) (1996) *Contemporary Archaeology in Theory: A Reader.* Oxford: Blackwell.

Hoffmann, P. (1985) 'On the stabilization of waterlogged oakwood with PEG: molecular size versus degree of degradation'. In Centre d'Étude et de Traitement des Bois Gorgés d'Eau (ed.), *Les Bois Gorgés d'Eau—Waterlogged wood. Proceedings of the 2nd ICOM Waterlogged Wood Working Group Conference, Grenoble, 1984*. Grenoble: Centre d'Étude et de Traitement des Bois Gorgés d'Eau, 95–115.

——(1986) 'On the stabilization of waterlogged oakwood with PEG. II. Designing a two-step treatment for multi-quality timbers'. *Studies in Conservation* 31: 103–13.

——(1988) 'On the stabilization of waterlogged oakwood with polyethylene glycol (PEG). III Testing the oligomers'. *Holzforschung* 42: 289–94.

——(1990) 'On the stabilization of waterlogged softwoods with polyethylene glycol (PEG). Four species from China and Korea'. *Holzforschung* 42: 87–93.

——(1998) 'Das Frachtschiff aus dem Teufelsmoor'. *Arbeitsblätter für Restauratoren* 31 (2): 270–6.

——(2001) 'On the conservation of ships with PEG: the Bremen Cog and beyond'. In B. A. Purdy (ed.), *Enduring records: The environmental and cultural heritage of wetlands*. Oxford: Oxbow, 295–302.

——(2009) 'On the efficiency of stabilization methods for large waterlogged wooden objects, and on how to choose a method'. In K. Straetkvern and D. J. Huisman (eds.), *Proceedings of the 10th ICOM Group on Wet Organic Archaeological Materials Conference, Amsterdam 2007.* Amersfoort: ICOM Committee for Conservation Working Group on Wet Organic Archaeological Materials.

——Singh, A., Kim, Y. S., Wi, S. G., Kim, I.-J., and Schmitt, U. (2004) 'The Bremen Cog of 1380—an electron microscopic study of its degraded wood before and after stabilization with PEG'. *Holzforschung* 58 (3): 211–18.

——Spriggs, J. A., Grant, T., Cook, C., and Recht, A. (eds.) (2002) *Proceedings of the 8th ICOM Group on Wet Organic Archaeological Materials Conference Stockholm 2001.* Bremerhaven: ICOM Committee for Conservation Working Group on Wet Organic Archaeological Materials.

Högberg, A., Puseman, K., and Yost, C. (2009) 'Integration of use-wear with protein residue analysis—a study of tool use and function in the south Scandinavian Early Neolithic'. *Journal of Archaeological Science* 36: 1725–37.

Hokkaido Maizou Bunkazai Senta (1996) *Misagawa Ryuiki no Iseki-gun (a group of sites of the Misawa River Basin)*, xviii. Sapporo: Hokkaido Archaeological Centre.

——(1997) *Chitose Shi, Bibi 8 Iseki Teichitsubu, Misagawa Ryuiki Gun (Bibi 8 site, Chitose City, the lower and wet area—report concerning the new Chitose airport)*, xx. Sapporo: Hokkaido Archaeological Centre.

Holtorf, C. (2007) *Archaeology is a brand! The meaning of archaeology in contemporary popular culture.* Oxford: Archaeopress.

Honegger, M. (2001) 'Marin NE—Les Piécettes au Néolithique: Une station littorale d´exception'. *Jahrbuch der Schweizerischen Gesellschaft für Ur- und Frühgeschichte* 84: 29–42.

Hooper-Greenhill, E. (1996) *Museums and their visitors.* London: Routledge.

——(2007) *Museums and education. Purpose, pedagogy, performance.* London: Routledge.

Hope, G. S., and Golson, J. (1995) 'Late Quaternary change in the mountains of New Guinea'. *Antiquity* 69: 818–30.

——and Tulip, J. (1994) 'A long vegetation history from lowland Irian Jaya, Indonesia'. *Palaeogeography Palaeoclimatology Palaeoecology* 109: 385–98.

Hosch, S., and Jacomet, S. (2004) 'Ackerbau und Sammelwirtschaft. Ergebnisse der Untersuchung von Samen und Früchten'. In S. Jacomet, U. Leuzinger, and

J. Schibler (eds.), *Die jungsteinzeitliche Seeufersiedlung Arbon-Bleiche 3*. Frauenfeld: Veröffentlichung des Amtes für Archäologie des Kantons Thurgau, 112–57.

——and Zibulski, P. (2003) 'The influence of inconsistent wet-sieving procedures on the macroremains concentration in waterlogged sediments'. *Journal of Archaeological Science* 30: 849–57.

Hourmouziades, G. H. (1996) *The prehistoric lakeside settlement of Dispilio (Kastoria).* Thessaloniki: Codex.

Howard, L. C., Wood, P. J., Greenwood, M. T., and Randell, H. M. (2008) 'Reconstructing riverine paleo-flow regimes using subfossil insects (Coleoptera and Trichoptera): The application of the LIFE methodology to paleochannel sediments'. *Journal of Paleolimnology* 42: 453–66.

Howard, P. (2003) *Heritage: Management, interpretation, identity.* London: Continuum.

Huber, B. (1967) 'Seeberg, Burgäschisee-Süd. Dendrochronologie'. In H. G. Bandi (ed.), *Seeberg Burgäschisee-Süd. Chronologie und Umwelt*. Berne: Acta Bernensia, 145–56.

——and Holdheide, W. (1942) 'Jahrringchronologische Untersuchungen an Hölzern der bronzezeitlichen Wasserburg Buchau im Federsee'. *Berichte der Deutschen Botanischen Gesellschaft* 60: 261–83.

Huber, R., Schaeren, G., Bleicher, N., Hochuli, S., and Eberli, U. (2009) 'Zum Stand der Pfahlbauforschung im Kanton Zug'. *Tugium* 25: 111–40.

Hudson, M. (1990) 'From Toro to Yoshinogari: Changing perspectives on Yayoi archaeology'. In G. L. Barnes (ed.), *Hoabinhian, Jomon, Yayoi, Early Korean States.* Oxford: Oxbow, 63–112.

Huffman, T. N. (2007) *Handbook to the Iron Age: The Archaeology of Pre-Colonial Farming Societies in Southern Africa*. Pietermaritzburg: University of KwaZulu-Natal Press.

Hughes, P. J., Sullivan, M. E., and Yok, D. (1991) 'Human induced erosion in a highlands catchment in Papua New Guinea: The prehistoric and contemporary records'. *Zeitschrift für Geomorphologie* 83: 227–39.

Hughes, R. H., Hughes, J. S., and Bernacsek, G. (1992) *A Directory of African Wetlands.* Gland: IUCN.

Huot, J. (1996) *Oueli: travaux de 1987 et 1989.* Paris: Éditions Recherche sur les Civilisations.

Hurcombe, L. M. (2007*a*) *Archaeological artefacts as material culture.* London: Routledge.

——(2007*b*) 'Plant processing for cordage and textiles using serrated edges: New chaînes opératoires suggested by combining ethnographic, archaeological and experimental evidence'. In P. Crombé and V. Beugnier (eds.), *Plant processing from a prehistoric and ethnographic perspective*. Oxford: Archaeopress, 41–66.

——(2007*c*) 'A sense of materials and sensory perception in concepts of materiality'. *World Archaeology* 39 (4): 532–45.

——(2008) 'Organics from inorganics: Using experimental archaeology as a research tool for studying perishable material culture'. *World Archaeology* 40 (1): 83–115.

Hüster-Plogmann, H. (1996) 'Correlations between sample size and relative abundance of fish bones: Examples from the excavations at Arbon/TG Bleiche 3, Switzerland'. *Archaeofauna* 5: 141–6.

——(2004) 'Fischfang und Kleintierbeute. Ergebnisse der Untersuchung von Tierresten aus den Schlämmproben'. In S. Jacomet, U. Leuzinger, and J. Schibler (eds.), *Die jungsteinzeitliche Seeufersiedlung Arbon-Bleiche 3*. Frauenfeld: Veröffentlichung des Amtes für Archäologie des Kantons Thurgau, 253–76.

Iba, I. (2005) 'The Awazu site, a shell-midden on the bottom of Lake Biwa, Japan'. *Journal of Wetland Archaeology* 5: 35–48.

Imamura, K. (1996*a*) 'Jomon and Yayoi: The transition to agriculture in Japanese prehistory'. In D. Harris (ed.), *The origins and spread of agriculture and pastoralism in Eurasia*. London: UCL, 442–64.

——(1996*b*) *Prehistoric Japan*. London: UCL.

Imazu, S., and Morgos, A. (2002) 'An improvement on the lacitol conservation method used for the conservation of archaeological waterlogged wood'. In P. Hoffmann, J. A. Spriggs, and T. Grant (eds.), *Proceedings of the 8th ICOM Group on Wet Organic Archaeological Materials, Stockholm 2001*. Bremerhaven: ICOM Committee for Conservation Working Group on Wet Organic Archaeological Materials, 413–19.

Ingold, T. (1993) 'The temporality of landscape'. *World Archaeology* 25 (2): 24–174.

——(1995) 'Building, dwelling, living: How animals and people make themselves at home in the world'. In M. Strathern (ed.), *Shifting contexts: Transformations in anthropological knowledge*. London: Routledge, 57–80.

——(2000) *Perceptions of the environment. Essays in livelihood, dwelling and skill.* London: Routledge.

Ingstad, A. S. (1977) *The discovery of a Norse settlement in America: Excavations at L'Anse aux Meadows, Newfoundland 1961–1968.* Oslo: Universitetsforlaget.

Inoue, T. (1999) 'Early irrigation systems of rice paddy fields in Japan'. In B. J. Coles, J. M. Coles, and M. S. Jørgensen (eds.), *Bog bodies, sacred sites and wetland archaeology*. Exeter: Wetland Archaeology Research Project, 115–20.

——(2001) 'Irrigation dams in the Yayoi period, Japan'. In B. Raftery and J. Hickey (eds.), *Recent developments in wetland research.* WARP Occasional Paper 14. Dublin: University College Dublin.

Iriarte, J., Holst, I., Lopez, J. M., and Cabrera, L. (2001) 'Subtropical wetland adaptations in Uruguay during the Mid-Holocene: an archaeobotanical perspective'. In B. A. Purdy (ed.), *Enduring records: The environmental and cultural heritage of wetlands*. Oxford: Oxbow, 61–70.

Irwin, G. (2004*a*) 'Artefacts of bone, tooth, pumice and pounamu'. In G. J. Irwin (ed.), *Kohika: The archaeology of a late Maori lake village in the Ngati Awa rohe, Bay of Plenty, New Zealand*. Auckland: Auckland University Press, 160–7.

——(ed.) (2004*b*) *Kohika.* Auckland: Auckland University Press.

——(2005) 'Kohika, a Late Maori lake village in Northern New Zealand'. *Journal of Wetland Archaeology* 5: 129–39.

——(2006) 'Voyaging and settlement'. In K. R. Howe (ed.), *Vaka Moana: Voyages of the ancestors*. Auckland: Bateman, 54–99.

IRWIN, G. HORROCKS, M., WILLIAMS, L. J., HALL, H. J., MCGLONE, M. S., and NICHOL, S. L. (2004) 'Evidence for diet, parasites, pollen, phytoliths, diatoms and starch grains in prehistoric coprolites from Kohika'. In G. J. Irwin (ed.), *Kohika: The archaeology of a late Maori lake village in the Ngati Awa rohe, Bay of Plenty, New Zealand*. Auckland: Auckland University Press, 217–38.

ISMAIL-MEYER, K. (2010) 'Mikromorphologische Analyse zweier Profilkolonnen aus den Tauchsondagen von 1999 und 2007'. In K. Altorfer (ed.), *Die prähistorischen Feuchtbodensiedlungen am Südrand des Pfäffikersees. Eine archäologische Bestandesaufnahme der Stationen Wetzikon-Robenhausen und Wetzikon-Himmerich*. Monographien der Kantonsarchäologie Zürich 41. Zurich: Direktion der Öffentlichen Bauten des Kantons Zürich, 86–96.

——and RENTZEL, P. (2004) 'Mikromorphologische Untersuchung der Schichtabfolge'. In S. Jacomet, U. Leuzinger, and J. Schibler (eds.), *Die jungsteinzeitliche Seeufersiedlung Arbon Bleiche 3: Umwelt und Wirtschaft*. Frauenfeld: Huber & Co., 66–80.

IVY, D., and BYRAM, S. (2001) 'Coquille cultural heritage and wetland archaeology'. In B. A. Purdy (ed.), *Enduring records: The environmental and cultural heritage of wetlands*. Oxford: Oxbow, 120–31.

JAANITS, L. (1984) 'Die kennzeichenende Züge der Siedlung Tamula'. *Fenno-ugri et slavi* 4: 183–93.

JACOB-FRIESEN, G. (1963) 'Kunststrassen durch die Moore'. In G. Jacob-Friesen (ed.), *Einführung in Niedersachsens Urgeschichte*. Hildesheim: Karl, 362–6.

JACOMET, S. (2004) 'Archaeobotany: A vital tool in the investigation of lake-dwellings'. In F. Menotti (ed.), *Living on the lake in prehistoric Europe: 150 years of lake-dwelling research*. London: Routledge, 162–77.

——(2007) 'Plant macrofossil methods and studies: Use in environmental archaeology'. In S. A. Elias (ed.), *Encyclopedia of Quaternary Science*. Oxford: Elsevier, 2384–412.

——and BROMBACHER, C. (2005*a*) 'Abfälle und Kuhfladen—Leben im neolithischen Dorf. Zu Forschungsergebnissen, Methoden und zukünftigen Forschungsstrategien archäobotanischer Untersuchungen von neolithischen Seeufer- und Moorsiedlungen'. *Jahrbuch der Schweizerischen Gesellschaft für Ur- und Frühgeschichte* 88: 7–39.

——(2005*b*) 'Reconstructing intra-site patterns in Neolithic lakeshore settlements: The state of archaeobotanical research and future prospects'. In P. Della Casa and M. Trachsel (eds.), *WES'04: Wetland economies and societies*. Zurich: Chronos, 69–94.

——and KREUZ, A. (1999) *Archäobotanik. Aufgaben, Methoden und Ergebnisse Vegetations- und Agrargeschichtlicher Forschungen*. Stuttgart: Eugen Ulmer.

——BROMBACHER, C., and DICK, M. (1989) *Archeobotanik am Zürichsee. Ackerbau, Sammelwirtschaft und Umwelt von neolithischen und bronzezeitlichen Seeufersiedlungen im Raum Zürich: Ergebnisse von Untersuchungen pflanzlicher Makroreste der Jahre 1979–1988*. Zurich: Orell Füssli.

——LEUZINGER, U., and SCHIBLER, J. (2004) *Die neolithische Seeufersiedlung Arbon Bleiche 3. Umwelt und Wirtschaft*. Frauenfeld: Huber & Co.

JANKOWSKA, D. (1998) 'Environmental conditions during the neolithisation of Pomerania'. In M. Zvelebil, L. Domańska, and R. Dennell (eds.), *Harvesting the sea, farming the forest: The emergence of Neolithic societies in the Baltic Region*. Sheffield: Sheffield Academic Press, 121–8.

JENNINGS, J. D. (1989) *Prehistory of North America*. Mountain View, Calif.: Mayfield.

Jensen, G. (2001) 'Macro wear patterns on Danish Late Mesolithic antler axes'. In A. M. Choyke and L. Bartosiewicz (eds.), *Crafting bone: Skeletal technologies through time and space*. Oxford: Archaeopress, 165–70.

Jiang, L. P. (2007) 'Excavation at the Shangshan site in Pujiang County, Zheijiang'. *Archaeology* 9: 7–18.

——and Liu, L. (2006) 'New evidence for the origins of sedentism and rice domestication in the lower Yangtze River, China'. *Antiquity* 80: 355–61.

——Zheng, Y. F., and Fang, X. M. (2004) *Kuahuqiao*. Beijing: Cultural Relics.

Jiao, L. (2010) 'Raising the medieval *Nanhai 1* wreck was a technical tour de force; now archaeologists are preparing to take the vessel apart plank by plank'. *Science* 328 (5977): 424–5.

Johns, D. A. (1998) 'Observations resulting from the treatment of waterlogged wood bowls in Aotearoa (New Zealand)'. In K. Bernick (ed.), *Hidden dimensions: The cultural significance of wetland archaeology*. Vancouver: University of British Columbia Press, 319–28.

——(2001) 'The conservation of wetland archaeological sites in New Zealand/ Aotearoa'. In B. A. Purdy (ed.), *Enduring records: The environmental and cultural heritage of wetlands*. Oxford: Oxbow, 246–53.

Johnston, R. B., and Cassavoy, K. A. (1978) 'The fishweirs at Atherley Narrows, Ontario'. *American Antiquity* 43: 697–709.

Jones, G. E. M. (2002) 'Weed ecology as a method for the archaeobotanical recognition of crop husbandry practices'. *Acta Palaeobotanica* 42: 185–93.

Jones, S. P., Slater, N. K. H., Jones, M., Ward, K., and Smith, A. (2009) 'Investigating the processes necessary for satisfactory freeze-drying of waterlogged archaeological wood'. *Journal of Archaeological Science* 36 (10): 2177–83.

Joosten, H. (2003*a*) 'International tendencies and perspectives of peatland use and conservation'. In A. Bauerochse and H. Haßmann (eds.), *Peatlands: Archaeological sites—archives of nature—nature conservation—wise use*. Rahden: Verlag Marie Leidorf, 225–32.

——(2003b) 'The wise use of peatlands: the backgrounds and principles of the IPS/ IMCG approach'. In A. Bauerochse and H. Haßmann (eds.) *Peatlands: Archaeological sites—archives of nature—nature conservation—wise use*. Rahden: Marie Leidorf, 233–40.

Jørgensen, M. S. (1988) 'Faerdsel over stenalderfjorden: Om den ældste vej i Tibirke. Fortidsminder og kulturhistorie'. *Antikvariske Studier* 9: 157–67.

Jousse, H., Obermaier, H., Raimbault, M., and Peters, J. (2008) 'Late Holocene economic specialisation through aquatic resource exploitation at Kobadi in the Méma, Mali'. *International Journal of Osteoarchaeology* 18: 549–72.

Jussila, T., and Kriiska, A. (2006) 'Pyyntikultuurin asuinpaikkojen rantasidonnaisuus. Uusia näkökulmia Suomen ja Viron kivi- ja varhaismetallikautisten asuinpaikkojen sijoittumiseen'. *Arkeologipäivät* 2005: 36–49.

——and Matiskainen, H. (2003) 'Mesolithic settlement during the Preboreal period in Finland'. In L. Larsson, H. Kindgren, K. Knutsson, D. Loeffler, and A. Åkerlund (eds.), *Mesolithic on the move*. Oxford: Oxbow, 664–70.

Kaeser, M.-A. (2002) 'L'Archéologie, les représentations collectives et la construction identitaire face aux contraintes matérielles'. *Les Nouvelles de l'Archéologie* 90: 12–17.

KAESER, M.-A. (2004*a*) 'Antiquare, Pfahlbauten und die Entstehung der urgeschichtlichen Wissenschaft: Die nationale und internationale Ausstrahlung der Antiquarischen Gesellschaft in Zürich'. In Antiquarische Gesellschaft in Zürich (ed.), *Pfahlbaufieber: Von Antiquaren, Pfahlbaufischern, Altertümerhändlern und Pfahlbaumythen*. Zurich: Chronos, 125–46.

——(2004*b*) *Les Lacustres: Archéologie et mythe national.* Lausanne: Presses Polytechniques et Universitaires Romandes.

——(2005) 'L'Histoire des recherches lacustres. De l'instrument disciplinaire à un historicisme réflexif'. In P. Della Casa and M. Trachsel (eds.), *WES'04: Wetland economies and societies*. Zurich: Chronos, 17–23.

——(2008*a*) 'De l'archétype villageois aux réseaux territoriaux. La dendrochronolgie et le temps oublié des habitats littoraux'. In A. Lehoerff (ed.), *Construire le temps. Histoire et méthodes des chronologies et calendriers des derniers millénaires avant notre ère en Europe occidentale*. Glux-en-Glenne: Collection Bibracte, 210–20.

——(2008*b*) *Visions d'une civilisation engloutie: La Représentation des villages lacustres de 1854 à nos jours.* Neuchâtel: Laténium.

——(2010) 'Une science universelle, ou "éminemment nationale"? Les congrès internationaux de préhistoire'. In W. Feuerhahn and P. Rabault-Feuerhahn (eds.), *La Fabrique internationale de la science: Les Congrès scientifiques de 1865 à 1945*. Paris: CNRS, 17–32.

KAMPFFMEYER, U. (1983) 'Der neolithische Siedlungsplatz Hüde I am Dümmer'. In G. Wegner (ed.), *Frühe Bauernkulturen in Niedersachsen*. Oldenburg: Archäologische Mitteilungen Nordwestdeutschland, 119–34.

KARSTEN, P., and KNARRSTRÖM, B. (2003) *The Tågerup Excavations. Skånska spå—arkeologi längs Västkustbanan.* Lund: National Heritage Board.

KAUL, F. (2004) 'Social and religious perceptions of the ship in Bronze Age Northern Europe'. In P. Clark (ed.), *The Dover Bronze Age boat in context: Society and water transport in prehistoric Europe*. Oxford: Oxbow, 122–37.

KAYE, B., and COLE-HAMILTON, D. J. (1998) 'Supercritical drying of waterlogged archaeological wood'. In K. Bernick (ed.), *Hidden dimensions: The cultural significance of wetland archaeology*. Vancouver: University of British Columbia Press, 329–39.

————and MORPHET, K. (2000) 'Supercritical drying: A new method for conserving waterlogged archaeological materials'. *Studies in Conservation* 45 (4): 233–52.

KELLER, F. (1854) 'Die keltische Pfahlbauten in den Schweizerseen'. *Mitteilungen derAntiquarischen Gesellschaft in Zürich* 9 (3): 65–100.

——(1866) *The lake-dwellings of Switzerland and other parts of Europe.* London: Longmans Green & Co.

——(1878) *The lake-dwellings of Switzerland and other parts of Europe.* 2nd edn. London: Longmans Green & Co.

KELLER-TARNUZZER, K. (1944) 'Pfyn-Breitenloo'. *Jahrbuch der Schweizerischen Gesellschaft für Ur- und Frühgeschichte* 35: 28–43.

KELLER-TARNUZZER, K. (1945) 'Pfahlbauten Arbon-Bleiche'. *Jahrbuch der Schweizerischen Gesellschaft für Ur- und Frühgeschichte* 36: 19–26.

KELLY, E. (2006) 'Secrets of the bog bodies: The enigma of the Iron Age explained'. *Archaeology Ireland* 20 (1): 26–30.

KELLY, F. (1997) *Early Irish farming.* Dublin: Institute of Advanced Studies.

Kelly, R. (1995) *The Foraging Spectrum: Diversity in hunter-gatherer lifeways.* Washington, DC: Smithsonian.

——(2001) *Prehistory of the Carson Desert and Stillwater Mountains: Environment, mobility, and subsistence in a Great Basin wetland.* Anthropological Paper 123. Salt Lake City: University of Utah.

Kelterborn, P. (1990) *Preconditions and strategies for experimental archaeology.* Paris: CNRS.

Kendall, T. (1997) *Kerma and the Kingdom of Kush, 2500–1500 bc: The archaeological discovery of an ancient Nubian empire.* Washington, DC: National Museum of African Art, Smithsonian.

Kenward, H. K., Hall, A. R., and Jones, A. K. C. (1980) 'A tested set of techniques for the extraction of plant and animal macrofossils from waterlogged archaeological deposits'. *Science and Archaeology* 22: 3–15.

————and Matthiesen, H. (2008) 'Patterns of early stage taphonomy in plant and insect macrofossils: Testing hypotheses in relation to post depositional mass decay of organic rich archaeological deposits'. In H. Kars and R. M. van Heeringen (eds.), *Preserving archaeological remains in situ. Proceedings of the 3rd conference, 7–9 December 2006, Amsterdam.* Amsterdam: Institute for Geo- and Bioarchaeology, VU University Amsterdam, 29–36.

——Hill, M., Jaques, D., Kroups, A., and Large, F. (2000) 'Evidence from beetles and other insects; evidence for living conditions on the crannog; Coleoptera analysis'. In A. Crone (ed.), *The history of Scottish lowland crannog: Excavations at Buiston, Ayrshire, 1989–90.* Monograph 4. Edinburgh: Scottish Trust for Archaeological Research, 230–47.

Kilian, M. R., Van Geel, B., and van der Plicht, J. (2000) '^{14}C AMS wiggle matching raised bog deposits and models of peat accumulation'. *Quaternary Science Reviews* 19: 1011–33.

Kimmig, W. (1992) *Die 'Wasserburg Buchau'eine spätbronzezeitliche Siedlung.* Stuttgart: Konrad Theiss.

Kinsky, M. (1995) 'Verbesserte Techniken der Feingrabung unter Wasser'. In Landesdenkmalamt Baden-Württemberg (ed.), *Archäologie unter Wasser 1.* Stuttgart: Landesdenkmalamt Baden-Württemberg, 150–4.

Kirk, R., and Daugherty, R. D. (2007) *Archaeology in Washington.* Seattle: University of Washington Press.

Kitagawa, H., and van der Plicht, J. (1998) 'A 40,000-year varve chronology from Lake Suigetsu, Japan: Extension of the ^{14}C calibration curve'. *Radiocarbon* 40: 505–15.

————(2000) 'Atmospheric radiocarbon calibration beyond 11,900 cal BP from Lake Suigetsu laminated sediments'. *Radiocarbon* 42 (3): 369–80.

Kite, M., and Thomson, R. (eds.) (2007) *Conservation of leather and related materials.* Oxford: Butterworth-Heinemann.

Klassen, L. (2008) 'Zur Bedeutung von Getreide in der Einzelgrabkultur Jütland'. In W. Dörfler and J. Müller (eds.), *Umwelt—Wirtschaft—Siedlungen im dritten vorchristlichen Jahrtausend Mitteleuropas und Südskandinaviens.* Neumünster: Wachholtz. 49–66.

Kobayashi, T. (2004) *Jomon reflections: Forager life and culture in the prehistoric Japanese archipelago.* Oxford: Oxbow.

KOBUSIEWICZ, M., and KABACIŃSKI, J. (1998) 'Some aspects of the Mesolithic–Neolithic Transition in the Western part of the Polish Lowlands'. In M. Zvelebil, L. Domańska, and R. Dennell (eds.), *Harvesting the sea, farming the forest: The emergence of Neolithic societies in the Baltic Region*. Sheffield: Sheffield Academic Press, 95–102.

KOCH, E. (1998) *Neolithic bog pots from Zealand, Møn, Lolland and Falster*. Copenhagen: Nordiske Fortidsminder.

——(1999) 'Neolithic offerings from the wetlands of eastern Denmark'. In B. J. Coles, J. M. Coles, and M. S. Jørgensen (eds.), *Bog bodies, sacred sites and wetland archaeology*. Exeter: Wetland Archaeology Research Project, 125–31.

KÖNINGER, J. (1995*a*) 'Die Tauchsondagen in den Ufersiedlungen von Bodman-Schachen I. Zusammenfassende Betrachtung'. In Landesdenkmalamt Baden-Württemberg (ed.), *Archäologie unter Wasser 1*. Stuttgart: Landesdenkmalamt Baden-Württemberg, 36–42.

——(1995*b*) 'Zum Fortgang der Tauchsondagen in den Ufersiedlungen von Bodman-Weiler I (Gem. Bodman-Ludwigshafen, Kr. Konstanz)'. *Nachrichtenblatt Arbeitskreis Unterwasserarchäologie* 2: 9–14.

——(1999) 'Von Fischen, Fallen und Faschinen. Neues aus den hallstattzeitliche Fundstellen von Oggelshausen-Bruckgraben, Kreis Biberach'. *Archäologische Ausgrabungen in Baden-Württemberg* 1999: 59–64.

——(2000) 'Zum vorlaeufigen Abschluss der Sondage in den eisenzeitlichen Fischfanglage bei Oggelshausen-Bruckgraben, Kreis Biberach'. *Archäologische Ausgrabungen in Baden-Württemberg* 2000: 59–62.

——(2002) 'Oggelshausen-Bruckgraben—Funde und Befunde aus einer eisenzeitlichen Fischfanglage im suedlichen Federseeried, Gemainde Oggelshausen, Kreis Biberach'. *Heimat- und Altertumsverein Heidenheim an der Brenz* 2001–2: 34–56.

——and SCHLICHTHERLE, H. (2006) 'Mesures de protection contre l'érosion des sites lacustres de la partie allemande des rives du Lac de Constance. État actuel des expériences et nouveaux projets'. In D. Ramseyer and M.-J. Roulière-Lambert (eds.), *Archéologie et érosion—2: Zones humides en péril*. Lons-le-Saunier: Centre Jurassien du Patrimoine, 81–7.

KONO, I. (1930) 'Preliminary report of the Nakai stone age site at Korekawa village, Aomori'. *Shizengaku Zasshi* 2 (4): 237–54.

KOPYTOFF, I. (1986) 'The cultural biography of things: Commoditization as process'. In A. Appadurai (ed.), *The social life of things: Commodities in cultural perspective*. Cambridge: Cambridge University Press, 64–91.

——(1987) 'Internal African frontier: The making of African political culture'. In I. Kopytoff (ed.), *The African frontier: The reproduction of traditional African societies*. Bloomington: Indiana University Press.

KORHOLA, A., TIKKANEN, M., and WECKSTRÖM, J. (2005) 'Quantification of Holocene lake-level changes in Finnish Lapland using a cladocera-lake depth transfer model'. *Journal of Paleolimnology* 34: 175–90.

KORMONDY, K. E., and BROWN, D. (1998) *Fundamentals of human ecology*. London: Prentice-Hall.

KORVIN-PIOTROVSKIY, A. G., and MENOTTI, F. (eds.) (2008) *The Tripolye Culture in Ukraine: The giant-settlement of Talianki*. Kiev: K-P.

KOSINTSEV, P. A. (1988) 'Golotsenovye ostatki krupnykh mlekopitayushchikh Zapadnoi Sibiri' [The Holocene remains of large mammals in Western Siberia]. In

A. V. Borodin (ed.), *Sovremennnoe sostoyanie i istoriya zhivotnogo mira Zapadno-Sibirskoi nizmennosti*. Sverdlovsk: Uralskoe Otdelenie Akademii Nauk, 32–51.

Kossian, R. (2003) 'The Neolithic settlement site "Hunte 1" near Lake Dümmer, in Diepholz District (Lower Saxony, Germany)—a survey'. In A. Bauerochse and H. Haßmann (eds.), *Peatlands: Archaeological sites—archives of nature—nature conservation—wise use*. Rahden: Marie Leidorf, 79–88.

——(2007) *Hunte 1: Ein mittel- bis spätneolitischer und frübronzezeitlicher Siedlungsplatz am Dümmer, Ldkr. Diepholz (Niedersachsen)—Die Ergebnisse der Ausgrabungen des Reichsamtes für Vorgeschichte in den Jahren 1938 bis 1940.* Hannover: Niedersächsisches Landesmuseum Hannover.

Krahn, C. (2006) *Die bandkeramischen Siedlungen im Schlangengrabental.* Mainz: Zabern.

Krauss, M., Schöbel, G., and Walter, P. (1999) 'Das Hornstaathous im Pfahlbaumuseum Unteruhldingen: Feldversuch und Bewohnung'. *Plattform* 7–8: 70–81.

Kriiska, A. (2003) 'Colonisation of the west Estonian archipelago'. In L. Larsson, H. Kindgren, K. Knutsson, D. Loeffler, and A. Åkerlund (eds.), *Mesolithic on the move*. Oxford: Oxbow, 20–8.

——Johanson, K., Saluäär, U., and Lõugas, L. (2002) 'The results of research of Estonian Stone Age'. *Archaeological field works in Estonia* 2002: 25–41.

——Lõugas, L., Lõhmus, M., and Mannermaa, K. J., K, (2007) 'New AMS dates from Estonian Stone Age burial sites'. *Estonian Journal of Archaeology* 11 (2): 83–121.

Kristiansen, K. (1984) 'Krieger und Häuptlinge in der Bronzezeit Dänemarks. Ein Beitrag zur Geschichte des bronzezeitlichen Schwertes'. *Jahrbuch des Römisch-Germanisches Zentralmuseum* 31: 187–208.

——(1998) 'The construction of a Bronze Age landscape. Cosmology, economy and social organisation in Thy, Northwestern Jutland'. In B. Hänsel (ed.), *Mensch und Umwelt in der Bronzezeit Europas*. Kiel: Oetker-Voges, 281–91.

Krizhevskaya, L. (1998) 'The rise of farming in the Northern Steppe Zone of the Black Sea'. In M. Zvelebil, L. Domańska, and R. Dennell (eds.), *Harvesting the sea, farming the forest: The emergence of Neolithic societies in the Baltic Region*. Sheffield: Sheffield Academic Press, 245–52.

Krushanov, A. I. (ed.) (1989) *The history of the USSR Far East from Prehistory up to the Seventeenth Century.* Moscow: Nauka.

Kruts, V. A., Korvin-Piotrovskiy, A. G., Menotti, F., Ryzhov, S. N., Chernovol, D. K., and Chabanyuk, V. V. (2008) 'The Tripolye Culture giant-settlement of Talianki: The 2008 investigations'. *Reports IANAS* 8: 4–59.

Kryvaltsevich, M. (1996) 'Bone and horn artefacts of Bronze Age from Lake Viachera'. In Navuka i Technika (ed.), *From the deepness of the ages. Our country: history and cultural studies collection*. Minsk: Navuka i Technika, 147–61.

Kryvaltsevich, N. N., Razlutskaya, A. A., and Bakharev, V. A. (2008) 'Nekotorye rezultaty arkheozoologicheskikh issledovanij na neoliticheskom poselenii Kuzmichi 1 (Predpolesye Belarusi)'. In RAN (ed.), *Chelovek, adoptaciya, kultura*. Moscow: Izdatelstvo RAN, 147–61.

Kuzman, P. (2009) 'Prehistoric pile-dwelling at the Ohrid Lake'. *Macedonian Archaeological News* 1 (4). Website <http://www.mav.mk>, accessed July 2011.

Kuzmin, Y. V. (1995) 'People and environment in the Russian Far East from Paleolithic to Middle Ages: Chronology, palaeogeography, interaction'. *GeoJournal* 35 (1): 79–83.

——(1998) 'Wetlands-associated sites in the Russian Far East: A review of environment, chronology, and paleoeconomy'. In K. Bernick (ed.), *Hidden dimensions: The cultural significance of wetland archaeology*. Vancouver: University of British Columbia Press, 56–63.

Kuzmina, S. A. (2003) 'Novye faunisticheskie dannye po rezul′tatam raskopok neoliticheskih pamjatnikov Smolenskoj i Pskovskoj oblastej'. *SPb* 2003: 226–32.

Labes, S. (2005) 'Endmesolithische Holzfunde von dem submarinen Fundplatz Timmendorf-Nordmole I'. *Bodendenkmalpflege in Mecklenburg-Vorpommern* 52: 111–18.

Lambert, J. B. (1997) *Traces of the past. Unravelling the secrets of archaeology through chemistry.* Reading, Mass.: Perseus.

Landmann, G., Reimer, A., Lemcke, G., and Kempe, S. (1996) 'Dating Late Glacial abrupt climate changes in the 14,570 yr long continuous varve record of Lake Van, Turkey'. *Palaeogeography, Palaeoclimatology, Palaeoecology* 122: 107–18.

Lane, T., and Coles, J. M. (eds.) (2002) *Through wet and dry.* Sleaford: Heritage Trust of Lincolnshire.

Langdon, P. G., Barber, K. E., and Lomas-Clarke, S. H. (2004) 'Reconstructing climate and environmental change in Northern England through chironomid and pollen analysis: evidence from Talkin Tarn, Cumbria'. *Journal of Paleolimnology* 32: 197–213.

Langemann, G., and Dempsey, H. (1993) 'The Vermilion Lake's Wetlands: interpreting 10,000 years of human occupation in Banff National Park, Alberta'. In R. W. Jamieson, S. Albonyi, and N. A. Mirau (eds.), *Culture and Environment: A fragile coexistence*. Calgary: Archaeological Association of the University, 237–45.

Larson, G., Albarella, U., Dobney, K., Rowley-Conwy, P., Schibler, J., Tresset, A., Vigne, J. D., Edwards, C. J., Schlumbaum, A., Dinu, A., Balacsescu, A., Dolman, G., Tagliacozzo, A., Manaseryan, N., Miracle, P., Van Wijngaarden-Bakker, L., Masseti, M., Bradley, D. G., and Cooper, A. (2007) 'Ancient DNA, pig domestication, and the spread of Neolithic into Europe'. *Proceedings of the National Academy of Sciences of the United States of America* 104 (39): 15276–81.

Larsson, L. (1998) 'Prehistoric wetland sites in Sweden'. In K. Bernick (ed.), *Hidden dimensions: The cultural significance of wetland archaeology*. Vancouver: University of British Columbia Press, 64–82.

——(2001) 'South Scandinavian wetland sites and finds from the Mesolithic and the Neolithic'. In B. A. Purdy (ed.), *Enduring records: The environmental and cultural heritage of wetlands*. Oxford: Oxbow, 158–71.

——(2003) 'The Mesolithic of Sweden in retrospesctive and progressive perspectives'. In L. Larsson, H. Kindgren, K. Knutsson, D. Loeffler, and A. Åkerlund (eds.), *Mesolithic on the move*. Oxford: Oxbow, pp. xxii–xxxii.

——(2007*a*) 'The ritual use of wetlands during the Neolithic: A local study in Southernmost Sweden'. In M. Lillie and S. Ellis (eds.), *Wetland archaeology & environments: Regional issues, global perspectives*. Oxford: Oxbow, 79–90.

——(2007*b*) 'Wetland and Ritual Deposits during the Neolithic: A Local Study in a Micro-environment of a Macro-phenomenon'. *Lund Archaeological Review* 2005–2006: 59–69.

——(2007*c*) 'Wetlands and major infrastructural programmes: Prehistoric wetland sites in excavation project in Scania, southernmost Sweden'. In J. W. Barber, C. Clark, M. Cressey, A. Crone, A. Hale, J. C. Henderson, R. A. Housley, R. Sands, and A. Sheridan (eds.), *Archaeology from the wetlands: Recent perspectives*. Edinburgh: Society of Antiquaries of Scotland, 31–9.

Larsson, M. (1998) 'Inland hunters in the Mesolithic of Central Sweden: Högby and Leksand settlement sites from the Boreal and Atlantic periods'. In M. Zvelebil, L. Domańska, and R. Dennell (eds.), *Harvesting the sea, farming the forest: The emergence of Neolithic societies in the Baltic Region*. Sheffield: Sheffield Academic Press, 151–64.

——(2003) 'Storlyckan. Investigations of an Early Mesolithic settlement site in Östergötland, Eastern Middle Sweden'. In L. Larsson, H. Kindgren, K. Knutsson, D. Loeffler, and A. Åkerlund (eds.), *Mesolithic on the move*. Oxford: Oxbow, 29–36.

——(2007) 'Mesolithic episodes. Three Mesolithic sites in Eastern Middle Sweden'. In C. Waddington and K. Pedersen (eds.), *Mesolithic studies in the North Sea Basin and beyond: Proceedings of a conference held at Newcastle in 2003*. Oxford: Oxbow, 40–8.

Lasker, G. W., and Mascie-Taylor, C. G. N. (eds.) (1993) *Research strategies in human biology: Field survey studies.* Cambridge: Cambridge University Press.

Lasota-Moskalewska, A. (1998) 'Archaeological reconstruction of animal husbandry at Deby in Kuyavia, Poland'. In M. Zvelebil, L. Domańska, and R. Dennell (eds.), *Harvesting the sea, farming the forest: The emergence of Neolithic societies in the Baltic Region*. Sheffield: Sheffield Academic Press, 135–6.

Lattimore, O. (1962) *Studies in frontier history: Collected papers, 1928–1958.* London: Oxford University Press.

Laughlin, W. S. (1975) 'Aleuts: ecosystem, Holocene and Siberian origin'. *Science* 189: 507–15.

Lawrence, M. J., and Bates, C. R. (2002) 'Acoustic ground discriminating techniques for submerged archaeological site investigations'. *Marine Technology Society Journal* 35: 65–73.

Le Bailly, M., and Bouchet, F. (2004) 'Étude paléoparasitologique des coprolithes humains'. In S. Jacomet, U. Leuzinger, and J. Schibler (eds.), *Die jungsteinzeitliche Seeufersiedlung Arbon-Bleiche 3*. Frauenfeld: Veröffentlichung des Amtes für Archäologie des Kantons Thurgau, 372–7.

——Leuzinger, U., and Bouchet, F. (2003) 'Dioctophymidae Eggs in Coprolites From Neolithic Site of Arbon-Bleiche 3 (Switzerland)'. *Journal of Parasitology* 89: 1073–6.

————Schlichtherle, H., and Bouchet, F. (2005) 'Diphyllobothrium: Neolithic Parasite?' *Journal of Parasitology* 91: 957–9.

——(2007) '"Crise économique" au Néolithique à la transition Pfÿn-Horgen (3400 bc): Contribution de la paléoparasitologie'. *Anthropozoologica* 42 (2): 175–85.

Legge, A. J., and Rowley-Conwy, P. A. (1988) *Star Carr revisited: A re-analysis of the large mammals.* London: Birkbeck College Press.

Lemcke, G., and Sturm, M. (1997) '^{18}O and trace element measurements as proxy for the reconstruction of climate changes at Lake Van (Turkey): Preliminary results'. In L. Dalfes, H. Nüzhet, G. Kukla, and H. Weiss (eds.), *Third Millennium bc climate change and Old World collapse.* Berlin: Springer, 653–78.

Lemdahl, G. (2004) 'Insect remains'. In S. Jacomet, U. Leuzinger, and J. Schibler (eds.), *Die jungsteinzeitliche Seeufersiedlung Arbon-Bleiche 3*. Frauenfeld: Veröffentlichung des Amtes für Archäologie des Kantons Thurgau, 365–71.

Lera, P., and Touchais, G. (2004) 'Les Bronze Moyen dans le bassin de Korçë à la lumière des fouilles de Sovjan'. In P. Cabanes and J.-L. Lamboley (eds.), *L'Illyrie méridionale et l'Épire dans l'Antiquité*. Paris: Actes du Colloque, 23–38.

Leuzinger, U. (2000) *Die jungsteinzeitliche Seeufersiedlung Arbon-Bleiche 3. Befunde.* Frauenfeld: Archäologie im Thurgau.

——(2001) 'Seesicht, verbaut . . . Leben im Pfahlbaudorf Arbon-Bleiche 3 vor 5400 Jahren'. *Plattform* 9–10: 94–6.

——(2002) 'Holzartefakte'. In A. De Capitani, S. Deschler-Erb, U. Leuzinger, E. Marti-Grädel, and J. Schibler (eds.), *Die jungsteinzeitliche Seeufersiedlung Arbon-Bleiche 3: Funde*. Frauenfeld: Amt für Archäologie des Kantons Thurgau, 76–114.

——(2004) 'Experimental and applied archaeology in lake-dwelling research'. In F. Menotti (ed.), *Living on the lake in prehistoric Europe: 150 years of lake-dwelling research*. London: Routledge, 237–50.

——(2007) *Pfyn Breitenloo: Die jungsteinzeitliche Pfahlbausiedlung.* Frauenfeld: Amt für Archäologie Thurgau.

——(2008) 'Die Pfahlbauer von Pfyn—Steinzeit live. Erlebnisbericht zur Pfahlbau-Fernsehsendung im Sommer 2007. Spielbein/Standbein. Living History—von den Mühen mit der Vergangenheit'. *Museumspädagogik aktuell* 81: 27–33.

Levy, J. (1982) *Social and religious organisation in Bronze Age Denmark: An analysis of ritual hoard finds.* BAR International Series 124. Oxford: Archaeopress.

Lewis, H. (2007) 'Pile dwellings, changing lake conditions and sediment deposition: preliminary soil micromorphology study of cultural deposits from underwater sites at Lake Luokesas, Molėtai Region, Lithuania'. *Journal of Wetland Archaeology* 7: 33–50.

Lignereux, Y., Vaquer, J., and Collogne, J. (2006) 'Traction animale et lésions osseuses. Quelques cas dans le Néolithique final languecocien (France)'. In P. Pétrequin, R.-M. Arbogast, A.-M. Pétrequin, S. Van Willigen, and M. Bailly (eds.), *Premiers chariots, premiers araires: La Diffusion de la traction animale en Europe pendant le IV^{e} et III^{e} millénaires avant notre ère*. Paris: CNRS, 31–7.

Lillie, M. (2007) '*In situ* preservation: Geo-archaeological perspectives on an archaeological Nirvana'. In M. Lillie and S. Ellis (eds.), *Wetland archaeology & environments: regional issues, global perspectives*. Oxford: Oxbow, 156–72.

——Smith, R., Reed, J. M., and Inglis, R. (2007) 'Monitoring *in situ* preservation on south-west Scottish crannogs'. In J. W. Barber, C. Clark, M. Cressey, A. Crone, A. Hale, J. C. Henderson, R. A. Housley, R. Sands, and A. Sheridan (eds.), *Archaeology from the wetlands: Recent perspectives*. Edinburgh: Society of Antiquaries of Scotland, 281–8.

Lin, H. D. (1998) *Studies on Liangzhu Culture.* Zhejiang: Education Publishing House.

Lobert, G. (1995) *Les Outils à moissonner en silex issus des sites lacustre alpins du Néolitique et de L'Âge du bronze.* Paris: Université de Paris I.

Lord, B. (ed.) (2007) *The manual of museum learning.* Plymouth: AltaMira.

Lotter, A. F., and Strum, M. (1994) 'The study of environmental dynamics by means of laminated sediments: results and Switzerland'. In S. Hicks, U. Miller and M. Saarnisto (eds.), *Laminated sediment*. Rixensart: PACT, 15–24.

Lourandos, H. (1983) 'Intensification: A late Pleistocene-Holocene archaeological sequence from southwestern Victoria'. *Archaeology in Oceania* 18: 81–97.

——(1987) 'Swamp managers of Southern Victoria'. In D. J. Mulvaney and J. P. White (eds.), *Australians to 1788*. Sydney: Fairfax, Syme, & Weldon, 293–307.

Louwe Kooijmans, L. P. (1987) 'Neolithic settlement and subsistence in the wetlands of the Rhine/Meuse delta of the Netherlands'. In J. M. Coles and A. J. Lawson (eds.), *European wetlands in Prehistory*. Oxford: Clarendon, 227–51.

——(1993) 'Wetland exploitation and upland relations of prehistoric communities in the Netherlands'. In J. Gardiner (ed.), *Flatlands and wetlands: Current themes in East Anglian archaeology*. Oxford: East Anglian Archaeology, 71–116.

——(1998) 'Understanding the Mesolithic/Neolithic frontier in the Lower Rhine Basin, 5300–4300 cal bc'. In M. Edmonds and C. Richards (eds.), *Understanding the Neolithic of north-western Europe*. Glasgow: Glasgow University Press, 407–27.

——(1999) 'Shippea Hill and after: Wetlands in north European prehistory and the case of the donken'. In J. M. Coles and P. Mellars (eds.), *World prehistory: Studies in memory of Grahame Clark*. Oxford: Oxford University Press, 107–24.

——(ed.) (2001*a*) *Hardinxveld-Giessendam De Bruin: Een kampplaats uit het Laat-Mesolithicum en het begin van de Swifterbant-cultuur*. Amersfoort: Rapportage Archeologische Monumentenzorg.

——(ed.) (2001*b*) *Hardinxveld-Giessendam Polderweg. Een mesolithisch jachtkamp in het rivierengebied (5500–5000 v. Chr.)*. Amersfoort: Rapportage Archeologische Monumentenzorg.

——(2003) 'The Hardinxveld sites in the Rhine/Meuse Delta, the Netherlands, 5500–4500 cal bc'. In L. Larsson, H. Kindgren, K. Knutsson, D. Loeffler, and A. Åkerlund (eds.), *Mesolithic on the move*. Oxford: Oxbow, 608–24.

——(2006) 'Les Débuts de la traction animale aux Pays-Bas et ses conséquences'. In P. Pétrequin, R.-M. Arbogast, A.-M. Pétrequin, S. Van Willigen, and M. Bailly (eds.), *Premiers chariots, premiers araires: La Diffusion de la traction animale en Europe pendant le IV^{e} et III^{e} millénaires avant notre ère*. Paris: CNRS, 191–206.

——(2007) 'Review of R. Van de Noort and A. O'Sullivan [2006] Rethinking wetland archaeology [Duckworth]'. *Journal of Wetland Archaeology* 7: 95–7.

——and Jongste, P. (eds.) (2006) *Schipluiden: A Neolithic settlement on the Dutch North Sea coast c. 3500 cal bc*. Leiden: Analecta Praehistorica Leidensia.

Loze, I. A. (2001) 'Some aspects of research on Middle Neolithic amber in the Lake Lubāns depression'. In A. Butrimas (ed.), *Baltic amber*. Vilnius: Vilnius Academy of Fine Arts Press, 125–33.

Lozovski, V. (1999) 'Archaeological and ethnographic data for fishing structures from northeastern Europe to Siberia and the evidence from Zamostje 2, Russia'. In B. J. Coles, J. M. Coles, and M. S. Jørgensen (eds.), *Bog bodies, sacred sites and wetland archaeology*. Exeter: Wetland Archaeology Research Project, 139–45.

——and Ramseyer, D. (1995) 'Le Site préhistorique de Zamostje'. *Archéologia* 31: 134–41.

Lozovski, V. (1998) 'Les objets en bois du site mésolithique de Zamostje 2'. *ArchéSitula* 25: 5–18.

Lübke, H. (2003) 'New investigations on submarine Stone Age settlements in the Wismar Bay Area'. In L. Larsson, H. Kindgren, K. Knutsson, D. Loeffler, and A. Åkerlund (eds.), *Mesolithic on the move*. Oxford: Oxbow, 633–42.

——(2005) 'Spät- und endmesolithische Küstensiedlungsplätze in der Wismarbucht. Neue Grabungsergebnisse zur Chronologie und Siedlungsweise'. *Bodendenkmalpflege in Mecklenburg-Vorpommern* 52: 83–110.

——(2006) 'Filling a gap—five years of underwater archaeological investigations on submarine Stone Age sites in Wismar Bay, Germany'. In A. Hafner, U. Niffeler, and U. Ruoff (eds.), *Die neue Sicht—Unterwasserarchäologie und Geschichtsbild*. Basel: Archäologie Schweiz, 64–9.

Lübke, H., and Terberger, T. (2005) 'Das Endmesolithikum in Vorpommern und auf Rügen im Lichte neuer Daten'. *Bodendenkmalpflege in Mecklenburg-Vorpommern* 52: 243–55.

Ludwig, H.-D. (1968) 'Permanent farming on Ukara: Impact of land shortage on husbandry practices'. In H. Ruthenberg (ed.), *Smallholder Farming and Smallholder Development in Tanzania*. Munich: Weltforum, 88–135.

Lüning, J. (1989) 'Westliche Nachbarn der bandkeramischen Kultur: La Hoguette und Limburg'. *Germania* 67 (2): 255–93.

Ma'at-Ka-Re Monges, M. (1998) *Kush, the Jewel of Nubia: Reconnecting the root system of African civilization*. London: Africa World Press.

McAdam, E. (1999) 'Talking to ourselves'. In J. Beavis and A. Hunt (eds.), *Communicating archaeology*. Oxford: Oxbow, 49–55.

McDermott, C. (2007) 'Plain and bog, bog and wood, wood and bog, bog and plain: Peatland archaeology in Ireland'. In J. W. Barber, C. Clark, M. Cressey, A. Crone, A. Hale, J. C. Henderson, R. A. Housley, R. Sands, and A. Sheridan (eds.) *Archaeology from the wetlands: Recent perspectives*. Edinburgh: Society of Antiquaries of Scotland, 17–30.

Macdonald, G., and Purdy, B. (1982) 'Florida's wet sites: where the fragile past survives'. *Early Man* 4 (4): 4–12.

McGahern, A., Edwards, C. J., Bower, M. A., Heffernan, A., Park, S. D. E., Brophy, P. O., Bradley, D. G., MacHugh, D. E., and Hill, E. W. (2006) 'Mitochondrial sequence diversity in extant Irish horse populations and in ancient horses'. *Animal Genetics* 37: 498–502.

McGrail, S. (1985) 'The Brigg "raft": Problems in reconstruction and in assessment of performance'. In S. McGrail and E. Kentley (eds.), *Sewn plank boats*. Oxford: British Archaeological Reports, 165–94.

——(2001) *Boats of the world: From the Stone Age to Medieval times*. Oxford: Oxford University Press.

——(2004) 'North-west European seagoing boats before AD 400'. In P. Clark (ed.), *The Dover Bronze Age boat in context: Society and water transport in prehistoric Europe*. Oxford: Oxbow, 51–66.

——(2006) *Ancient Boats and Ships*. Oxford: Oxbow.

McIntosh, R. J. (1998) *Peoples of the Middle Niger*. Oxford: Blackwell.

McIntosh, S. K. (ed.) (1999*a*) *Beyond Chiefdoms: Pathways to Complexity in Africa*. Cambridge: Cambridge University Press.

——(1999*b*) 'Floodplains and the development of complex society: Comparative perspectives from the West African semi-arid tropics'. In E. Bacus and L. Lucero (eds.), *Complex polities in the ancient tropical world*. Arlington: American Anthropological Association, 151–65.

McKee, E. (1974) *The building and trials of the replica of an ancient boat: The Gokstad Faering. ii. The sea trials.* Greenwich: Maritime Monographs and Reports.

McKerrell, H., Roger, E., and Varsanyi, A. (1972) 'The acetone-rosin method for conservation of waterlogged wood'. *Studies in Conservation* 17: 111–25.

McMillan, A. D., and St. Claire, D. E. (1982) *Alberni Prehistory: Archaeological and ethnographic investigations on Western Vancouver Island*. Port Alberni: Theytus.

——and Yellowhorn, E. (2004) *First peoples in Canada*. Vancouver: Douglas & McIntyre.

Macphail, R. I. (1994) 'Soil micromorphology investigations in archaeology, with special reference to drowned coastal sites in Essex'. *SEESOIL* 10: 13–29.

——(2009) 'Marine inundation and archaeological sites: First results from the partial flooding of Wallsea Island, Essex, UK'. *Antiquity* 83 (319). Project Gallery website <http://antiquity.ac.uk/projgall/macphail/index.html>, accessed July 2011.

——Courty, M. A., and Gebhardt, A. (1990) 'Soil micromorphological evidence of early agriculture in north-west Europe'. *World Archaeology* 22: 53–69.

Madsen, D. B. (1982) 'Get it where gettin's good: A variable model of Great Basin subsistence of settlement based on data from the eastern Great Basin'. In D. B. Madsen and J. O'Connell (eds.), *Man and environment in the Great Basin.* Washington, DC: Society for American Archaeology, 207–26.

Magny, M. (1992) 'Holocene lake-level fluctuations in Jura and the northern subalpine ranges, France: regional pattern and climatic implications'. *Boreas* 21: 58–83.

——(1993) 'Solar influences on Holocene climatic changes illustrated by correlations between past lake-level fluctuations and the atmospheric ^{14}C-record'. *Quaternary Research* 40: 1–9.

——(1995) *Une histoire du climat: Des derniers mammouths au siècle de l'automobile.* Paris: Éditions Errance.

——(2004*a*) 'The contribution of palaeoclimatology to the lake-dwellings'. In F. Menotti (ed.), *Living on the lake in prehistoric Europe: 150 years of lake-dwelling research*. London: Routledge, 132–43.

——(2004*b*) 'Holocene climatic variability as reflected by mid-European lake-level fluctuations, and its probable impact on prehistoric human settlements'. *Quaternary International* 113: 65–79.

——(2006) 'Holocene fluctuations of lake levels in west-central Europe: Methods of reconstruction, regional pattern, palaeoclimatic significance and forcing factors'. In S. Elias (ed.), *Encyclopedia of Quaternary Science.* Amsterdam: Elsevier.

——Aalbersberg, G., Bégeot, C., Benoit-Ruffaldi, P., Bossuet, G., Disnar, J. R., Heiri, O., Laggoun-Defarge, F., Mazier, F., Millet, F., Peyron, O., Vannière, B., and Walter-Simonnet, A. V. (2006*a*) 'Environmental and climatic changes in the Jura mountains (eastern France) during the Late glacial-Holocene transition: A multi-proxy record from Lake Lautrey'. *Quaternary Science Reviews* 25: 414–45.

——Bégeot, C., Peyron, O., Richoz, I., Marguet, A., and Billaud, Y. (2005) 'Habitats littoraux et histoire des premières communautés agricoles au Néolithique et à l'Âge

du Bronze: Une mise en perspective paléoclimatique'. In P. Della Casa and M. Trachsel (eds.), *WES'04: Wetland economies and societies*. Zurich: Chronos, 133–42.

Magny, M., Leuzinger, U., Bortenschlager, S., and Haas, J. N. (2006*b*) 'Tripartite climate reversal in Central Europe 5600—5300 years ago'. *Quaternary Research* 65: 3–19.

——Peyron, O., Gauthier, E., Rouèche, H., Bordon, A., Billaud, Y., Chapron, E., Marguet, A., Pétrequin, P., and Vannière, B. (2009) 'Quantitative reconstruction of climatic variations during the Bronze and early Iron Ages, based on pollen and lake-level data in the NW Alps, France'. *Quaternary International* 200: 102–10.

Maier, U. (1999) 'Agricultural activities and land use in a Neolithic village around 3900 B.C.: Hornstaad Hörnle IA, Lake Constance, Germany'. *Vegetation History and Archaeobotany* 8: 87–94.

——(2001) Archäobotanische Untersuchungen in der neolithischen Ufersiedlung Hornstaad-Hörnle IA am Bodensee. In U. Maier and R. Vogt (eds.), *Botanische und pedologische Untersuchungen zur Ufersiedlung Hornstaad-Hörnle IA, Siedlungsarchäologie im Alpenvorland VI*. Stuttgart: Konrad Theiss, 9–384.

——and Vogt, R. (2001*a*) *Botanische und Pedologische Untersuchungen zur Ufersiedlung Hornstaad-Hörnle 1A*. Siedlungsarchäologie im Alpenvorland 6. Stuttgart: Konrad Theiss, 9–456.

——(2001*b*) 'Reconstructing the Neolithic landscape at Western Lake Constance'. In S. Rippon (ed.), *Estuarine archaeology: The Severn and beyond*. Exeter: Severn Estuary Levels Research Committee, 121–30.

Mallory, J., and McNeill, T. (1991) *The archaeology of Ulster: From colonisation to plantation*. Belfast: Queen's University of Belfast, Institute of Irish Studies.

Maltby, E. (2009) 'The changing wetland paradigm'. In E. Maltby and T. Barker (eds.), *The wetlands handbook*. Oxford: Blackwell, 3–42.

Maltby, M. (ed.) (2006) *Integrating zooarchaeology*. Oxford: Oxbow.

Manen, J.-F., Bouby, L., Dalnoki, O., Marinval, P., Turgay, M., and Schlumbaum, A. (2003) 'Microsatellites from archaeological *Vitis vinifera* seeds allow a tentative assignment of the geographical origin of ancient cultivars'. *Journal of Archaeological Science* 30 (6): 721–9.

Manley, J. (1993) *The Atlas of Past Worlds: A comparative chronology of human history 2000 bc–ad 1500*. London: Cassell.

Manning, S. W., and Bruce, M. J. (2009) *Tree-rings, kings, and Old World archaeology and environment. Papers presented in honour of Peter Jan Kuniholm*. Oxford: Oxbow.

Marchant, R. (2007) 'Late Holocene landscape change around Bwindi-Impenetrable Forest, Central Africa: Human dimensions in palaeoecological research from tropical wetlands'. In M. Lillie and S. Ellis (eds.), *Wetland archaeology & environments: Regional issues, global perspectives*. Oxford: Oxbow, 275–88.

Marquardt, W. H., and Walker, K. J. (2001) 'Pineland: A coastal wet site in Southwest Florida'. In B. A. Purdy (ed.), *Enduring records: The environmental and cultural heritage of wetlands*. Oxford: Oxbow, 48–60.

Marsden, S. (2001) 'The heritage management of wetlands: Legislative designation and protection, a viewpoint from England and Wales'. In B. J. Coles and A. Olivier

(eds.), *The heritage management of wetlands in Europe*. Exeter: Europae Archaeologiae Consilium and WARP, 7–15.

Marshall, Y. (2009) 'Community archaeology'. In B. Cunliffe, C. Gosden, and R. A. Joyce (eds.), *The Oxford handbook of archaeology*. Oxford: Oxford University Press, 1078–102.

Mårtenssen, L. (2007) 'Investigating the function of Mediterranean Bronze Age textile tools using wool and flax fibres'. *Experimentelle Archäologie in Europa* 6: 97–106.

——Nosch, M.-L., and Andersson Strand, B. (2009) 'Shape of things: Understanding a Loom Weight'. *Oxford Journal of Archaeology* 28 (4): 373–98.

Martinelli, N. (2001) 'Le indagini dendrocronologiche e le datazioni radiometriche'. In P. Frontini (ed.), *Castello del Vho': Campagne di scavo 1996–1999*. Milan: Scavi delle civiche raccolte archeologiche, 215–23.

——(2005) 'Dendrocronologia e archaeologia: situazione e prospettive della ricerca in Italia'. In P. Attema, A. Nijboer, and A. Zifferero (eds.), *Communities and settlements from the Neolithic to the Early Medieval Periods*. BAR International Series 1452. Oxford: Archaeopress, 347–448.

——and Kromer, B. (1999) 'High Precision ^{14}C dating of a new tree-ring Bronze Age chronology from the pile-dwelling of Frassino'. In J. Evin, C. Oberlin, and P. Douglas (eds.), *^{14}C et l'archeologie*: Lyons: Revue D'Archeometrie Supplementaire, 119–22.

Martínez Straumann, S. (2004) 'Makro- und mikroskopische Untersuchungen von Speisekrusten aus Keramikgefässen'. In S. Jacomet, U. Leuzinger, and J. Schibler (eds.), *Die jungsteinzeitliche Seeufersiedlung Arbon-Bleiche 3*. Frauenfeld: Veröffentlichung des Amtes für Archäologie des Kantons Thurgau, 277–83.

Maruyama, R. (ed.) (1984) *Awazu Kaiduka Kotei Iseki (Awazu shell middens in the bottom of Lake Biwa)*. Shiga: The Board of Education, Shiga Prefecture Government.

Marzatico, F. (2001) 'Mediterranean Europe'. In B. J. Coles and A. Olivier (eds.), *The heritage management of wetlands in Europe*. Exeter: Europae Archaeologiae Consilium and WARP, 91–8.

Marzatico, F. (2004) 150 years of lake-dwelling research in Northern Italy. In F. Menotti (ed.), *Living on the lake in prehistoric Europe: 150 years of lake-dwelling research*. London: Routledge, 83–97.

——(2006) 'L'araire et le joug de Lavagnone et de Fiavé (Italie)'. In P. Pétrequin, R.-M. Arbogast, A.-M. Pétrequin, S. Van Willigen, and M. Bailly (eds.), *Premiers chariots, premiers araires: La diffusion de la traction animale en Europe pendant le IV^{e} et III^{e} millénaires avant notre ère*. Paris: CNRS, 63–71.

Mathewson, K. (1984) *Irrigation horticulture in Highland Guatemala: The tablon system of Panajachel.* Boulder: Westview.

Mathieu, J. R. (ed.) (2002) *Experimental archaeology: Replicating past objects, behaviours and processes.* BAR International Series 1035. Oxford: Archaeopress.

Matson, R. G., and Coupland, G. (1995) *The prehistory of the Northwest Coast.* San Diego: Academic Press.

Matsui, A. (1992) 'Wetland sites in Japan'. In B. J. Coles (ed.), *The Wetland Revolution in Prehistory*. Exeter: Prehistoric Society, 5–14.

Matsui, A. (1999) 'Wetland archaeology in Japan. Key sites and features in the research history'. In B. J. Coles, J. M. Coles, and M. S. Jørgensen (eds.), *Bog bodies, sacred sites and wetland archaeology.* Exeter: Wetland Archaeology Research Project, 147–56.

——(2009) 'Exploitation of plants and animals at the Jomon wetland site of Sakuramachi in Toyama, Japan'. In G. Cooney, K. Becker, J. Coles, M. Ryan, and S. Sievers (eds.), *Relics of Old Decency: Archaeological studies in later prehistory. A Festschrift for Barry Raftery.*Dublin: Wordwell, 67–77.

Matsuyama City Board of Education (1976) *Kodera Site II.* Matsuyama City: Matsuyama City Board of Education.

Matthiesen, H. (2004) '*In situ* measurement of soil pH'. *Journal of Archaeological Science* 31: 1373–81.

——Gregory, D., Jensen, P., and Sørensen, B. (2004) 'Environmental monitoring at Nydam, a waterlogged site with weapon sacrifices from the Danish Iron Age. I: A comparison of methods used and results from undisturbed conditions'. *Journal of Wetland Archaeology* 4: 55–74.

Maurin, B. (1998) *Le long pont de Losa.* Dax: Société de Borda.

——(2006) 'Les Sites du Lac de Sanguinet (Landes, France)'. In A. Hafner, U. Niffeler, and U. Ruoff (eds.), *Die neue Sicht—Unterwasserarchäologie und Geschichtsbild.* Basel: Archäologie Schweiz, 92–6.

Mauvilly, M., and Boisaubert, J.-L. (2005) 'Entre terre et lacs dans les régions de Morat et d'Estavayer-le-Lac (FR): quelle image après 30 ans de recherches assidues?' In P. Della Casa and M. Trachsel (eds.), *WES'04: Wetland economies and societies.* Zurich: Chronos, 179–84.

May, E., and Jones, M. (2006) *Conservation science heritage materials.* Cambridge: RSC Publishing.

Mazurkevich, A., and Dolbunova, E. (2011) 'Underwater Investigations in Northwest Russia: Lacustrine archaeology of Neolithic pile dwellings'. In J. Benjamin, C. Bonsall, C. Pickard, and A. Fischer (eds.), *Submerged Prehistory*. Oxford: Oxbow, 158–72.

Mead, H. M. (1995) *Te Toi Whakairo: The art of Maori carving.* Auckland: Reed.

Médard, F. (2005) 'Les Textiles préhistoriques. Anatomie des écorces et analyse des traitements mis en oeuvre pour en extraire la matière textile'. In P. Della Casa and M. Trachsel (eds.), *WES'04: Wetland economies and societies*. Zurich: Chronos, 99–104.

Mellars, P. (1998) 'Postscript: Major issues in the interpretation of Star Carr'. In P. Mellars and P. Dark (eds.), *Star Carr in context: New archaeological and palaeoecological investigations at the Early Mesolithic site of Star Carr, North Yorkshire.* Cambridge: MacDonald Institute, 215–41.

——and Dark, P. (1998) *Star Carr in context: New archaeological and palaeoecological investigations at the Early Mesolithic site of Star Carr, North Yorkshire*. Cambridge: MacDonald Institute.

Menotti, F. (1999) 'The abandonment of the ZH-Mozartstrasse Early Bronze Age lake-settlement: GIS computer simulations of the lake-level fluctuation hypothesis'. *Oxford Journal of Archaeology* 18 (2): 143–55.

——(2001*a*) *'The missing period': Middle Bronze Age lake-dwellings in the Alps.* Oxford: Archaeopress.

——(2001*b*) 'The 'Pfahlbauproblem' and the history of the lake-dwelling research in the Alps'. *Oxford Journal of Archaeology* 20 (4): 319–28.

——(2002) 'Climatic change, flooding and occupational hiatus in the lake-dwelling central European Bronze Age'. In R. Torrence and J. Grattan (eds.), *Natural disasters and cultural change*. London: Routledge, 235–49.

——(2003) 'Cultural response to environmental change in the Alpine lacustrine regions: The displacement model'. *Oxford Journal of Archaeology* 22 (4): 375–96.

——(2004*a*) 'Displacement, readaptation and cultural continuity: A lake-dwelling perspective'. In F. Menotti (ed.), *Living on the lake in prehistoric Europe: 150 years of lake-dwelling research*. London: Routledge, 207–17.

——(ed.) (2004*b*) *Living on the lake in prehistoric Europe*. London: Routledge.

——(2004*c*) 'Poggiomarino'. In P. Bogucki and P. Crabtree (eds.), *Ancient Europe, 8000 B.C. to A.D. 1000: An encyclopedia of the barbarian world*. Farmington Hills, Mich.: Charles Scribner's Sons, 42–5.

——(2009) 'Climate variations in the Circum-Alpine region and their influence on the Neolithic–Bronze Age lacustrine communities: Displacement and/or cultural adaptation'. *Documenta Praehistorica* 36: 61–6.

——Baubonis, Z., Brazaitis, D., Higham, T. F. G., Kvedaravicius, M., Lewis, H., Motuzaite, G., and Pranckenaite, E. (2005) 'The first lake-dwellers of Lithuania: Late Bronze Age pile settlements on Lake Luokesas'. *Oxford Journal of Archaeology* 24 (4): 381–403.

——and Pranckenaite, E. (2008) 'Lake-dwelling building techniques in prehistory: Driving wooden piles into lacustrine sediments'. *EuroREA* 5: 3–7.

Meskell, L. (2001) 'Archaeologies of identity'. In I. Hodder (ed.), *Archaeological theory today*. Cambridge: Polity, 187–213.

Meuerers-Balke, J., and Lüning, J. (1990) 'Experimente zur frühen Landwirtschaft'. *Experimentelle Archäologie in Deutschland* 4: 82–92.

Middleton, W. D., and Douglas-Price, T. (1996) 'Identification of activity areas by multi-element characterization of sediments from modern and archaeological house floors using inductively coupled plasma-atomic emission spectroscopy'. *Journal of Archaeological Science* 23: 673–87.

Milanich, J. T. (1998) *Florida's Indians from ancient times to the present.* Florida: University Press of Florida.

Millett, M., and MacGrail, S. (1987) 'The archaeology of the Hasholme logboat'. *Archaeological Journal* 144: 69–155.

Minc, L. D. (1986) 'Scarcity and survival: The role of oral tradition in mediating subsistence crises'. *Journal of Anthropological Archaeology* 5: 39–113.

Mitchell, P. J. (2005) *African Connections: Archaeological Perspectives on Africa and the Wider World.* Walnut Creek, Calif.: AltaMira.

Mithen, S. (2000) *Hunter-gatherer landscape archaeology: The Southern Hebrides Mesolithic Project, 1988–98.* Cambridge: McDonald Institute.

Mitsch, W. J., and Gosselink, J. G. (1993) *Wetlands*. 2nd edn. New York: Van Nostrand Reinhold.

————(2000) *Wetlands*. 3rd edn. New York: John Wiley & Sons.

————(2007) *Wetlands*. 4th edn. New York: John Wiley & Sons.

Mitsch, W. J., and Gosselink, J. G. Li Zhang, L., and Anderson, C. J. (2009) *Wetland ecosystems*. New York: John Wiley.

Miyaji, A. (1999) 'Storage pits and the development of plant food management in Japan during the Jomon period'. In B. J. Coles, J. M. Coles, and M. S. Jørgensen (eds.), *Bog bodies, sacred sites and wetland archaeology*. Exeter: Wetland Archaeology Research Project, 165–70.

Mobley, C. M., and McCallum, W. M. (2001) 'Prehistoric intertidal fish traps from Central Southeast Alaska'. *Canadian Journal of Archaeology* 25 (1–2): 28–52.

Møller Hansen, K. (2003) 'Pre-Boreal elk bones from Lundby Mose'. In L. Larsson, H. Kindgren, K. Knutsson, D. Loeffler, and A. Åkerlund (eds.), *Mesolithic on the move*. Oxford: Oxbow, 521–6.

Molleson, T. (1994) 'The eloquent bones of Abu Hureyra'. *Scientific American* 271 (2): 70–5.

Momber, G. (2000) 'Drowned and deserted: A submerged prehistoric landscape in the Solent, England'. *International Journal of Nautical Archaeology* 29 (1): 86–99.

——(2007) 'Submerged in Mesolithic archaeology'. In C. Waddington and K. Pedersen (eds.), *Mesolithic studies in the North Sea Basin and beyond: Proceedings of a conference held at Newcastle in 2003.* Oxford: Oxbow, 33–9.

Money, R. P., Wheeler, B. D., Baird, A. J., and Heathwaite, A. L. (2009) 'Replumbing wetlands—managing water for the restoration of bogs and fens'. In E. Maltby and T. Barker (eds.), *The wetlands handbook*. Oxford: Blackwell, 755–79.

Monnier, J.-L., Pétrequin, P., Richard, A., Pétrequin, A.-M., and Gentizon, A.-L. (1991) *Construire une maison 3000 ans avant J.C.: Le Lac de Chalain au Neolithique.* Paris: Errance.

Moodie, D. W., Catchpole, A. J. W., and Kerry, A. (1992) 'Northern Athapaskan oral tradition and the White River Volcano'. *Ethnohistory* 39 (2): 148–71.

Moore, C. (2008) 'Old Routes to New Research: The Edercloon Wetland Excavations in County Longford'. In J. O'Sullivan and M. Stanley (eds.), *Roads rediscovery and research. Proceedings of a public seminar on archaeological discoveries on national road schemes, August 2007.* Dublin: National Roads Authority

Moore, J. H. (1994) 'Putting anthropology back together again: The ethnogenetic critique of cladistic theory'. *American Anthropologist* 96: 370–96.

——(2001) 'Ethnogenetic patterns in native North America'. In J. E. Terrell (ed.), *Archaeology, language and history: Essays on culture and ethnicity*. Westport, Conn.: Bergin & Garvey, 30–56.

Moorman, B. J. (2001) 'Ground-penetrating radar applications in paleolimnology'. In W. M. Last and J. P. Smol (eds.), *Tracking environmental change using lake sediments.* i. *Basin analysis, coring, and chronological techniques.* Dordrecht: Kluwer Academic.

Moran, E. F. (1990) *The ecosystem approach in anthropology.* Ann Arbor: University of Michigan Press.

——(1995) *Comparative analysis of human societies: Toward common standards for data collection and reporting.* Boulder: L. Rienner.

——(2000) *Human adaptability: An introduction to ecological anthropology.* Boulder: Westview.

MORDANT, D., and MORDANT, C. (1992) 'Noyen-sur-Seine: A Mesolithic waterside settlement'. In B. J. Coles (ed.), *The Wetland Revolution in Prehistory*. Exeter: Prehistoric Society, 55–64.

MORIKAWA, M., and HASHIMOTO, S. (1994) *Torihama Shell Midden—The Jomon Time Capsule*. Tokyo: Yomiuri Shimbun.

MORLEY, S. G., and BRAINERD, G. W. (1983) *The Ancient Maya*. Stanford: Stanford University Press.

MORREN, G. (1986) *The Miyanmin: Human ecology of a Papua New Guinea society*. Ann Arbor: University of Michigan Press.

MORRISON, I. (1985) *Landscape with lake dwellings: The crannogs of Scotland*. Edinburgh: Edinburgh University Press.

MORSE, E. S. (1879) *Shell mounds of Omori*. Tokyo: Science Department, University of Tokyo.

MORTENSEN, M. N., EGSGAARD, H., HVILSTED, S., SHASHOUA, Y., and GLASTRUP, J. (2007) 'Characterisation of the polyethylene glycol impregnation of the Swedish warship Vasa and one of the Danish Skuldelev Viking ships'. *Journal of Archaeological Science* 34 (8): 1211–18.

MOSS, M. L., and CANNON, A. (eds.) (2011) *The archaeology of North Pacific fisheries*. Fairbanks: University of Alaska Press.

——and ERLANDSON, J. M. (1998) 'A comparative chronology of Northwest Coast fishing features'. In K. Bernick (ed.), *Hidden dimensions: The cultural significance of wetland archaeology*. Vancouver: University of British Columbia Press, 180–97.

——ERLANDSON, J. M., and STUCKENRATH, R. (1990) 'Wood stake weirs and salmon fishing on the Northwest Coast: Evidence from Southeast Alaska'. *Canadian Journal of Archaeology* 14: 143–58.

MÜLLER, M., MURPHY, B., BURGHAMMER, M., SNIGIREVA, I., RIEKEL, C., GUNNERWEG, J., and PANTOS, E. (2006) 'Identification of single archaeological textile fibres from the Cave of Letters using synchrotron radiation microbeam diffraction and microfluorescence'. *Applied Physics* A 83: 183–8.

MUNRO, R. (1882) *Ancient Scottish lake-dwellings or crannogs*. Edinburgh: David Douglas.

——(1890) *The lake-dwellings of Europe*. London: Cassell.

——(1912) *Palaeolithic man and terramara settlements in Europe*. Edinburgh: Oliver & Boyd.

MUSIL, R. R. (1995) *Adaptive transitions and environmental change in the Northern Great Basin: A view from Diamond Swamp*. Eugene: University of Oregon.

NADEL, D., WEISS, E., SIMCHONI, O., TSATSKIN, A., DANIN, A., and KISLEV, M. (2004) 'Stone Age hut in Israel yields world's oldest evidence of bedding'. *Proceedings of the National Academy of Sciences* 101 (17): 6821–6.

NAKAGAWA, T., KITAGAWA, H., YASUDA, Y., TARASOV, P. E., GOTANDA, K., and SAWAI, Y. (2005) 'Pollen/event stratigraphy of the varved sediment of Lake Suigetsu, central Japan from 15,701 to 10,217 SG vyr BP (Suigetsu varve years before present): Description, interpretation, and correlation with other regions'. *Quaternary Science Reviews* 24: 1691–701.

Nakamura, Y., and Kondo, Y. (2005) *Nauman zou no karyudo wo motomete* (*In search of the Nauman Elephant's hunters*). Shinano Town: Nojiriko Nauman Elephant Museum.

Nara National Research Institute (2008) *Survey report on the construction materials of the buried buildings at the Kurumidate Site.* Kita Akita City: Nara National Research Institute.

Nazarea, V. D. (1999) *Ethnoecology: Situated knowledge/located lives.* Tucson: University of Arizona Press.

Needham, J. (1971) *Science and civilisation in China*. Cambridge: Cambridge University Press.

Nekrasov, A. E. (2003) 'Kostnye Ostatki Ptits iz Golotsenovykh Mestonakhozhdeny Urala i Zapadnoi Sibiri'. In N. G. Smirnov and K. I. Ushakova (eds.), *Chetvertichnaya Paleozoologiya na Urale*. Yekaterinburg: Izdatelstvo Uralskogo Universiteta, 158–70.

Netting, R. (1977) *Cultural ecology.* Menlo Park, Calif.: Cummings.

Newsom, L. A., and Purdy, B. A. (1990) 'Florida canoes: A maritime heritage from the past'. *Florida Anthropologist* 43: 164–80.

Nicholas, G. P. (1988) 'Ecological leveling: The archaeology and environmental dynamics of early Postglacial land-use'. In G. P. Nicholas (ed.), *Holocene human ecology in northeastern North America*. New York: Plenum, 257–96.

——(1992) 'Directions in wetlands research'. *Man in the Northeast* 43: 1–9.

——(1998) 'Wetlands and hunter-gatherers: A global perspective'. *Current Anthropology* 39: 720–33.

——(2001) 'Wet sites, wetland sites, and cultural resource management strategies'. In B. A. Purdy (ed.), *Enduring records: The environmental and cultural heritage of wetlands*. Oxford: Oxbow, 262–70.

——(2007) 'Prehistoric hunter-gatherers in wetland environments: Mobility/sedentism and aspects of socio-political organisation'. In M. Lillie and S. Ellis (eds.), *Wetland archaeology and environments: regional issues, global perspectives*. Oxford: Oxbow, 245–57.

Nielsen, S. (1966) 'Eksperiment'. *Skalk* 3: 13–23.

Niesiołowska-Śreniowska, E. (1998) 'The neolithization of Polish territory'. In M. Zvelebil, L. Domańska, and R. Dennell (eds.), *Harvesting the sea, farming the forest: The emergence of Neolithic societies in the Baltic Region*. Sheffield: Sheffield Academic Press, 137–40.

Niewiarowski, W., Noryśkiewicz, B., Piotrowski, W., and Zajączkowski, W. (1992) 'Biskupin fortified settlement and its environment in the light of new environmental and archaeological studies'. In B. J. Coles (ed.), *The wetland revolution in prehistory.* 81–92. Exeter: Prehistoric Society

Nishida, I. (2010) *Report on the overview of Higashimyo Sites Excavation Survey.* Saga City: Board of Education.

Nishiguchi, Y., Miyano, J., and Uenishi, M. (1984) *Yamaga.* Osaka: Centre for Cultural Heritage.

Noe-Nygaard, N., and Hede, M. U. (2006) 'The first appearance of cattle in Denmark occurred 6000 years ago: An effect of cultural or climate and environmental changes'. *Geografiska Annaler Series A—Physical Geography* 88A: 87–95.

NORDQUIST, D. (1976) '45SN100—the Biederbost site, Kidd's Duvall site'. In D. R. Croes (ed.), *The excavation of water-saturated archaeological sites (wet sites) on the Northwest Coast of North America*. Ottawa: National Museum of Man Mercury, 186–200.

NORDQVIST, B. (1995) 'The Mesolithic settlements of the west coast of Sweden—with special emphasis on chronology and topography of coastal settlements'. In A. Fischer (ed.), *Man and sea in the Mesolithic: Coastal settlement above and below present sea level*. Oxford: Oxbow, 185–96.

O'REILLY STERNBERG, H. (1998) *A Agua e o Homem na Várzea do Careiro*. Belém: Museu Paraense do Emilio Goeldi.

ODUM, H. T. (1971) *Environment, power and society*. New York: Wiley-Interscience.

OETTING, A. C. (1989) *Villages and wetlands adaptations in the Northern Great Basin: Chronology and land use in the Lake Abert-Chewaucan Marsh—Lake County, Oregon*. Eugene: University of Oregon.

OLAUSSON, D. (1992) 'The archaeology of the Bronze Age cultural landscape—research goals, methods and results'. In L. Larsson, J. Callmer, and B. Stjernquist (eds.), *The archaeology of the cultural landscape*. Stockholm: Almqvist & Wiksell, 251–82.

OLIVIER, A. (2001) 'Europae Archaeologiae Consilium. A strategy for the heritage management of wetlands'. In B. J. Coles and A. Olivier (eds.), *The heritage management of wetlands in Europe*. Exeter: Europae Archaeologiae Consilium and WARP, 185–91.

——(2004) 'Great expectations: The English Heritage approach to the management of the historic environment in England's wetlands'. *Journal of Wetland Archaeology* 4: 155–68.

——and VAN DE NOORT, R. (2002) *A strategy for the conservation and management of monuments at risk in England's wetlands*. London: English Heritage and Exeter University.

ORME, B. J., COLES, J. M., and SILVESTER, R. J. (1983) 'Meare Village East 1982'. *Papers* 9: 49–74.

OSHIBKINA, S. V. (1989) 'The material culture of the Veretye-type sites in the region to the east of Lake Onega'. In C. Bonsall (ed.), *The Mesolithic in Europe*. Edinburgh: John Donald, 402–13.

OSIPOWICZ, G. (2005) 'A method of wood tar production without the use of ceramic'. *EuroREA* 2: 11–17.

O'SULLIVAN, A. (1990) 'Wood in archaeology'. *Archaeology Ireland* 4 (2): 69–73.

——(1995) 'Wood technology and the use of raw materials'. *Medieval Archaeology* 38: 19–54.

——(1996) 'Neolithic, Bronze Age and Iron Age woodworking techniques'. In B. Raftery (ed.), *Trackway excavations in the Mount Dillon bogs, Co.Longford, 1985–1991*. Dublin: Crannóg Publication and Irish Archaeological Wetland Unit, 291–342.

——(1998) *The archaeology of lake settlement in Ireland*. Dublin: Discovery Programme/Royal Irish Academy.

——(2000) *Crannogs: Lake-dwellings of early Ireland*. Dublin: Town House.

——(2001*a*) 'Crannogs in late medieval Gaelic Ireland, c.1350–c.1600'. In P. J. Duffy, D. Edwards, and E. Fitzpatrick (eds.), *Gaelic Ireland: Land, lordship and settlement, c.1250–c.1660*. Dublin: Four Courts, 397–417.

O'Sullivan, A. (2001*b*) 'Crannogs—places of resistance in the contested landscapes of early modern Ireland'. In B. Bender and M. Winer (eds.), *Contested landscapes: Landscapes of movement and exile*. Oxford: Berg, 87–101.

——(2001*c*) *Foragers, farmers and fishers in a coastal landscape: An intertidal archaeological survey of the Shannon Estuary*. Dublin: Royal Irish Academy.

——(2003*a*) 'A day in the life of a medieval fisherman . . . and of intertidal archaeologists'. In J. Fenwick (ed.), *Lost and found: Discovering Ireland's past*. Dublin: Wordwell, 233–46.

——(2003*b*) 'Place, memory and identity among estuarine fishing communities: Interpreting the archaeology of early medieval fish weirs'. *World Archaeology* 35: 449–68.

——(2005) 'Medieval fish traps on the Shannon Estuary, Ireland: Interpreting people, place and identity in estuarine landscapes'. *Journal of Wetland Archaeology* 5: 65–77.

——(2007) 'Exploring past people's interactions with wetland environments in Ireland'. *Proceedings of the Royal Irish Academy* 107C: 147–203.

——and Breen, C. (2007) *Maritime Ireland: An archaeology of coastal communities.* Stroud: Tempus.

——and Daly, A. (1999) 'Prehistoric and Medieval coastal settlement and wetland exploitation in the Shannon estuary, Ireland'. In B. J. Coles, J. M. Coles, and M. S. Jørgensen (eds.), *Bog bodies, sacred sites and wetland archaeology*. Exeter: Wetland Archaeology Research Project, 177–84.

——and Van de Noort, R. (2007) 'Temporality, cultural biography and seasonality: Rethinking time in wetland archaeology'. In J. W. Barber, C. Clark, M. Cressey, A. Crone, A. Hale, J. C. Henderson, R. A. Housley, R. Sands, and A. Sheridan (eds.), *Archaeology from the wetlands: Recent perspectives.* Edinburgh: Society of Antiquaries of Scotland, 67–77.

Pääbo, S., Poinar, H., Serre, D., Jaenicke-Després, V., Hebler, J., Rohland, N., Kuch, M., Krause, J., Vigilant, L., and Hofreiter, M. (2004) 'Genetic analyses from ancient DNA'. *Annual Review of Genetics* 38: 645–79.

Paardekooper, R. (2005) 'The process of fulling of wool'. *EuroREA* 2: 67–78.

Painter, T. J. (1991) 'Preservation in peat'. *Chemistry & Industry* 17: 421–4.

——(1995) 'Chemical and microbiological aspects of the preservation process in *Sphagnum* peat'. In R. C. Turner and R. G. Scaife (eds.), *Bog bodies: New discoveries and new perspectives*. London: British Museum Press, 88–99.

Papayannis, T., and Pritchard, D. E. (2008) *Culture and wetlands—a Ramsar guidance document.* Gland: Ramsar Convention.

Pardoe, C. (1988) 'The cemetery as symbol. The distribution of prehistoric Aboriginal burial grounds in southeastern Australia'. *Archaeology in Oceania* 23 (1): 1–16.

Paret, O. (1942) 'Die Pfahlbauten. Ein Nachruf'. *Schriften des Verein für Geschichte des Bodensees und seiner Umgebung* 68: 75–84.

——(1958) *Le Mythe des cités lacustres.* Paris: Dunod.

Parker, A. G., Davies, C., and Wilkinson, T. J. (2006) 'The early to mid-Holocene moist period in Arabia: Some recent evidence from lacustrine sequences in eastern and south-western Arabia'. *Proceedings of the Seminar for Arabian Studies* 36: 243–55.

Parker Pearson, M., and Sydes, R. E. (1997) 'The Iron Age enclosures and prehistoric landscape at Sutton Common, S. Yorkshire'. *Proceedings of the Prehistoric Society* 63: 221–59.

——Chamberlain, A. T., Collins, M. J., Cox, C., Craig, G., Craig, O. E., Hiller, J., Marshall, P., Mulville, J., and Smith, H. (2007) 'Further evidence for mummification in Bronze Age Britain'. *Antiquity* 81 (312), <http://www.antiquity.ac.uk/ProjGall/parker/index.html>, accessed July 2011.

——————Craig, O. E., Marshall, P., Mulville, J., Smith, H., Chenery, C., Cook, G., Craig, G., Evans, J., Hiller, J., Montgomery, J., Schwenninger, J.-L., Taylor, G., and Wess, T. (2005) 'Evidence for mummification in Bronze Age Britain'. *Antiquity* 79: 529–46.

Parsons, J. J., and Denevan, W. M. (1989) 'Pre-Columbian ridged fields'. In W. M. Denevan (ed.), *Hispanic lands and peoples: Selected writings of James J. Parsons*. Boulder: Westview, 211–21.

Peacock, E., and Schofield, G. (1997) 'A survey of conservation methods for Trondheim's water-degraded archaeological rope'. In P. Hoffmann, T. Grant, J. A. Spriggs, and P. Daley (eds.), *Proceedings of the 6th ICOM Group on Wet Organic Archaeological Materials Conference, York 1996*. Bremerhaven: ICOM Committee for Conservation Working Group on Wet Organic Archaeological Materials, 13–26.

Pearson, M., and Shanks, M. (2001) *Theatre/Archaeology*. London: Routledge.

Pearson, R. (1992) *Ancient Japan*. Washington: Sackler Gallery.

Pedersen, L. (1999) 'Fishing structures in wetlands'. In B. J. Coles, J. M. Coles, and M. S. Jørgensen (eds.), *Bog bodies, sacred sites and wetland archaeology*. Exeter: Wetland Archaeology Research Project, 185–90.

Pelillo, A. (ed.) (2009) *Guide to the archaeological open-air museums in Europe. liveArch and EXARC.* Modena: Nuovografica Carpi.

Pendergast, D. M., Graham, E., Calvera, R. J., and Jardines, M. J. (2001) 'Houses in the sea: Excavation and preservation at Los Buchillones, Cuba'. In B. A. Purdy (ed.), *Enduring records: The environmental and cultural heritage of wetlands*. Oxford: Oxbow, 71–82.

——(2002) 'The houses in which they dwelt: The excavation and dating of Taino wooden structures at Los Buchillones, Cuba'. *Journal of Wetland Archaeology* 2: 61–75.

Peng, D. (ed.) (1988) *Ships of China*. Beijing: Chinese Institute of Navigation.

Perini, R. (1984) *Scavi archeologici nella zona palafitticola di Fiavè-Carera.* Trento: Servizio Beni culturali della Provincia di Trento.

——(1987) *Scavi archeologici nella zona palafitticola di Fiavè-Carera.* Trento: Servizio Beni culturali della Provincia di Trento.

Peros, M. C., Graham, E., and Davis, A. M. (2006) 'Stratigraphic investigations at Los Buchillones, a Taìno site on the north coast of central Cuba: Evidence from geochemistry, mineralogy, paleontology, and sedimentology'. *Geoarchaeology* 21: 403–28.

Petréquin, A.-M., and Petréquin, P. (1984) *Habitat lacustre du Bénin: Une approche enthnoarchéologique.* Paris: ADPF.

————(1988) *Le Néolithique des lacs: Préhistoire des lacs de Chalain et de Clairvaux (4000–2000 av. J.-C.).* Paris: Errance.

PETRÉQUIN, A.-M., and PETRÉQUIN, P. and WELLER, O. (2006) *Objets de pouvoir en Nouvelle-Guinée. Étude ethnoarchéologique d'un système de signes sociaux (Catalogue de la donation Anne-Marie et Pïerre Pétrequin, Musée d'Archéologie Nationale de Saint-Germain-en-Laye).* Paris: Réunion des Musées Nationaux et CTHS.

PÉTREQUIN, P. (1984) *Gens de l'eau, gens de la terre: Ethno-archéologie des communautes lacustres.* Paris: Hachette.

——(1995) 'Management of architectural woods and variations in population density in the fourth and third millennia BC (Lakes Chalain and Clairvaux, Jura, France)'. *Journal of Anthropological Archaeology* 14: 1–19.

——(ed.) (1997) *Les Sites littoraux néolithiques de Clairvaux et Chalain (Jura), III, Chalain 3, 3200–2900 av. J.-C.* Paris: Éditions de la Maison des Sciences de l'Homme.

——(2001) 'Gestion du patrimoine archéologique en milieu humide: Le Cas de la France et des lacs de Chalain et de Clairvaux'. In B. J. Coles and A. Olivier (eds.), *The heritage management of wetlands in Europe*. Exeter: Europae Archaeologiae Consilium and WARP, 117–24.

——(2006) 'La Protection du Lac de Chalain (Fontenu, Jura, France), dix ans après (1995–2004)'. In D. Ramseyer and M.-J. Roulière-Lambert (eds.), *Archéologie et érosion—2: Zones humides en péril.* Lons-le-Saunier: Centre Jurassien du Patrimoine, 89–97.

——(2008) 'Archéologie expérimentale et grand public'. *MARQ Arqueologia y Museos* 3: 33–61.

——and BAILLY, M. (2004) 'Lake-dwelling research in France: From climate to demography'. In F. Menotti (ed.), *Living on the lake in prehistoric Europe: 150 years of lake-dwelling research.* London: Routledge, 36–49.

——and PÉTREQUIN, A.-M. (1993) *Écologie d'un outil: La Hache de pierre en Iran Jaya (Indonésie).* Paris: CNRS.

——MAGNY, M., and BAILLY, M. (2005) 'Habitat lacustre, densité de population et climat. L'exemple du Jura français'. In P. Della Casa and M. Trachsel (eds.), *WES'04: Wetland economies and societies*. Zurich: Chronos, 143–68.

——PÉTREQUIN, A.-M., and BAILLY, M. (2006*a*) 'Vues du Jura français: Les Premières tractions animales au Néolithique en Europe occidentale'. In P. Pétrequin, R.-M. Arbogast, A.-M. Pétrequin, S. Van Willigen and M. Bailly (eds.), *Premiers chariots, premiers araires: La Diffusion de la traction animale en Europe pendant le IVe et IIIe millénaires avant notre ère*. Paris: CNRS, 361–98.

PÉTREQUIN, P., LOBERT, G., MAITRE, A. and MONNIER, J.-L. (2006*b*) 'Les outils à moissonner et la question de l'introduction de l'araire dans le Jura (France)'. In P. Pétrequin, R.-M. Arbogast, A.-M. Pétrequin, S. Van Willigen, and M. Bailly (eds.), *Premiers chariots, premiers araires: La Diffusion de la traction animale en Europe pendant le IVe et IIIe millénaires avant notre ère*. Paris: CNRS, 107–20.

——ARBOGAST, R.-M., PÉTREQUIN, A.-M., VAN WILLIGEN, S. and BAILLY, M. (eds.) (2006*c*) *Premiers chariots, premiers araires: La diffusion de la traction animale en Europe pendant les IVe et IIIe millénaires avant notre ère.* Paris: CNRS.

——PÉTREQUIN, A.-M., ARBOGAST, R.-M., MARÉCHAL, D. and VIELLET, A. (2006*d*) 'Travois et jougs néolithiques du lac de Chalain à Fontenu (Jura, France)'.

In P. Pétrequin, R.-M. Arbogast, A.-M. Pétrequin, S. Van Willigen, and M. Bailly (eds.), *Premiers chariots, premiers araires: La Diffusion de la traction animale en Europe pendant le IV^e et III^e millénaires avant notre ère*. Paris: CNRS, 87–105.

——Arbogast, R.-M., Bourquin-Mignot, C., Duplaix, A., Martineau, R., Pétrequin, A.-M., and Viellet, A. (2002) 'Le Mythe de la stabilité: Déséquilibres et réajustements d'une communauté agricole néolithique dans le Jura français, du 32e au 30e siècle av. J.-C.' In H. Richard and A. Vignot (eds.), *Equilibres et ruptures dans les écosystèmes durant les 20 derniers millénaires: Durabilité et mutation*. Paris: Les Belles Lettres, 175–90.

Petrie, G. (1853) 'On crannoge islands'. *Proceedings of the Royal Irish Academy* 16: 214–15.

Pfister, C. (2001) 'Klimawandel in der Geschichte Europas. Zur Entwicklung und zum Potenzial der historischen Klimatologie'. *Österreichische Zeitschrift für Geschichtswissenschaften* 12 (2): 7–42.

Pflederer, T. (2009) 'Dokumentation neuerer Einbaumfunde in Bayern'. In C. S. Sommer and E. J. Greipl (eds.), *Unterwasser- und Feuchtbodenarchäologie in Bayern*. Munich: Bayerische Bodendenkmalpflege, 45–70.

Phillips, C. (2000) *Waihou journeys: The archaeology of 400 years of Maori settlement.* Auckland: Auckland University Press.

——Johns, D., and Allen, H. (2002) 'Why did Māori bury artefacts in the wetlands of pre-contact Aotearoa/New Zealand?' *Journal of Wetland Archaeology* 2: 39–60.

Pieper, P. (2001) 'Die Moorleiche von Neu Versen, genannt 'Roter Franz', im Landesmuseum Hannover. Anthropologisch-medizinische Befunde'. *Die Kunde* 52: 99–109.

——(2003) 'Peat bog corpses'. In A. Bauerochse and H. Haßmann (eds.), *Peatlands: Archaeological sites—archives of nature—nature conservation—wise use*. Rahden: Marie Leidorf, 107–14.

——Möhlenhoff, P., Behre, K.-E., Parpatt, P.-M., Schübel, F., and Schübel, J. (1999) 'Moor-Leichen'. In F. Both, M. Fansa, S. Heinrichs, and C. Ritzau (eds.), *Weder See noch Land. Moor—eine verlorene Landschaft*. Oldenburg: Isensee, 62–79.

Piezonka, H. (2008) 'Neue AMS-Daten zur frühneolithischen Keramikentwicklung'. *Estonian Journal of Archaeology* 12 (2): 67–113.

Pigorini, L. (1882–3) 'Terramara dell'eta' del Bronzo situata in Castioni dei Marchesi'. *Atti Reale Accademia dei Lincei* III: VIII.

Pilcher, J. R., Baillie, M. G. L., Schmidt, B., and Becker, B. (1984) 'A 7272 year tree ring chronology for Western Europe'. *Nature* 312: 150–2.

Pillonel, D. (2007*a*) 'Constrution des ponts celtiques et gallo-romains'. In M. Schwab (ed.), *La Tène: La Recherche—les questions—les réponses*. Bienne: Musée Schwab, 86–97.

——(2007*b*) *Technologie et usage du bois au Bronze final.* Hauterive: Office et musée cantonal d'archéologie de Neuchâtel.

——(2009) 'Un image emblématique de La Tène: Le Bois mortaisés a la lumière technologique'. In M. Honneger, D. Ramseyer, G. Kaenel, B. Arnold, and M.-A. Kaeser (eds.), Neuchâtel: Office et musée cantonal d'archéologie de Neuchâtel.

Pingel, C. (2009) 'Sag mir, welche Funde Du magst und ich sag Dir, wer Du bist—Wege zu einer "Experimentellen Archäologie der Wahrnehmung"'. *Experimentelle Archäologie in Europa* 8: 131–44.

Piotrowski, W. (1998) 'The importance of the Biskupin wet site for twentieth-century Polish archaeology'. In K. Bernick (ed.), *Hidden dimensions: The cultural significance of wetland archaeology*. Vancouver: University of British Columbia Press, 89–106.

Plets, R. M. K., Dix, J. K., Adams, J. R., and Best, A. I. (2008) '3D reconstruction of a shallow archaeological site from high-resolution acoustic imagery: The *Grace Dieu*'. *Applied Acoustics* 69: 399–411.

Plowman, J. E., Bryson, W. G., and Jordan, T. W. (2000) 'Application of proteomics for determining protein markers for wool quality traits'. *Electrophoresis* 21 (9): 1899–906.

Pluciennik, M. (2008) 'Hunter-gatherers to farmers?' In A. Jones (ed.), *Prehistoric Europe: Theory and practice*. Oxford: Wiley-Blackwell, 16–34.

Pohl, M. D., and Bloom, P. (1996) 'Prehistoric Maya farming in the wetlands of Northern Belize: More data from Albion Island'. In S. L. Fedick (ed.), *The managed mosaic: Ancient Maya agriculture and resource use*. Salt Lake City: University of Utah Press, 145–64.

——Pope, K. O., Jones, J. G., Jacob, J. S., Piperno, D. R., deFrance, S. D., Lentz, D. L., Gifford, J. A., Danforth, M. E., and Josserand, J. K. (1996) 'Early agriculture in the Maya Lowlands'. *Latin American Antiquity* 74 (4): 355–72.

Pollmann, B., Doppler, T., Schibler, J. and Röder, B. (2007) 'Die Rolle der experimentellen Archäologie in systemdynamischen Modellierungen zu neolithischen Feuchtbodensiedlungen'. *Experimentelle Archäologie in Europa* 2007: 77–85.

——Jacomet, S., and Schlumbaum, A. (2005) 'Morphological and genetic studies of waterlogged *Prunus* species from the Roman vicus Tasgetium, Switzerland'. *Journal of Archaeological Science* 32: 1471–80.

Pope, K. O., Pohl, M. D. and Jacob, J. S. (1996) 'Formation of ancient Maya wetland fields: Natural and anthropogenic processes'. In S. L. Fedick (ed.), *The managed mosaic: Ancient Maya agriculture and resource use*. Salt Lake City: University of Utah Press, 165–76.

Porro, A. (1994) 'Social organization and political power in the Amazon floodplain. The ethnohistorical sources'. In A. Roosevelt (ed.), *Amazonian Indians from prehistory to present: Anthropological perspectives*. Tucson: University of Arizona Press, 79–94.

Poska, A., Saarse, L., and Veski, S. (2004) 'Reflections of pre- and early-agrarian human impact in the pollen diagrams of Estonia'. *Palaeogeography Palaeoclimatology Palaeoecology* 209: 37–50.

Pournelle, J. R. (2007) 'KLM to CORONA: A bird's eye view of cultural ecology and early Mesopotamian urbanization'. In E. Stone (ed.), *Settlement and Society: Essays dedicated to Robert McCormick Adams*. Los Angeles: Cotsen Institute, UCLA, 29–62.

Powell, J. M. (1982) 'History of plant use and man's impact on the vegetation'. In J. L. Gressitt (ed.), *Biogeography and ecology of New Guinea*. The Hague: Junk, 207–27.

Price, T. D. (2003) 'Hunter-gatherers in transition: Introduction'. In L. Larsson, H. Kindgren, K. Knutsson, D. Loeffler, and A. Åkerlund (eds.), *Mesolithic on the move*. Oxford: Oxbow, 565–8.

Prickett, N. J. (1982) 'An archaeologists' guide to the Maori dwelling'. *New Zealand Journal of Archaeology* 4: 111–47.

Pruneti, P. (2002) 'Palafitte a Poggiomarino sul Sarno: protostoria ai piedi del Vesuvio'. *Archeologia Viva* 94: 72–6.

Pruvost, M., Schwarz, R., Bessa Correira, V., Champlot, S., Grange, T., and Geigl, E. M. (2008) 'DNA diagenesis and palaeogenetic analysis: critical assessment and methodological progress'. *Palaeogeography, Palaeoclimataology, Palaeoecology* 266: 211–19.

Pryor, F. (1998) *Etton: excavations at a Neolithic causewayed enclosure near Maxey, Cambridgeshire, 1982–87.* London: English Heritage.

——(2001) *Archaeology and Environment of the Flag Fen Basin.* London: English Heritage.

——(2005) *Flagfen: Life and Death of a Prehistoric Landscape.* Stroud: Tempus.

——and Taylor, M. (1992) 'Flag Fen, Fengate, Peterborough II: Further definition, techniques and assessment'. In B. J. Coles (ed.), *The wetland revolution in prehistory.* Exeter: Prehistoric Society, 37–46.

Purdy, B. A. (1987) 'Investigations at Hontoon Island, an archaeological wet site in Volusa County Florida; an overview and chronology'. *Florida Anthropologist* 40: 4–12.

——(1991) *The art and archaeology of Florida's wetlands.* Boca Raton: CRC.

——(1992) 'Florida's archaeological wet sites'. In B. J. Coles (ed.), *The wetland revolution in prehistory*. Exeter: Prehistoric Society, 113–23.

——(2001) 'Archaeological investigations of water-saturated deposits in Volusia County, Florida: Groves Orange Midden on Lake Monroe'. In B. A. Purdy (ed.), *Enduring records: The environmental and cultural heritage of wetlands*. Oxford: Oxbow, 38–47.

Pydyn, A. (2007) 'The lake-dwellings and lakeside settlements of Poland'. In J. W. Barber, C. Clark, M. Cressey, A. Crone, A. Hale, J. C. Henderson, R. A. Housley, R. Sands, and A. Sheridan (eds.), *Archaeology from the wetlands: Recent perspectives*. Edinburgh: Society of Antiquaries of Scotland, 323–31.

Quilliec, B. (2001) 'Les Épées du Bronze final et les voies fluviales et maritimes'. In J. L'Helgouach and J. Briard (eds.), *Systèmes fluviaux, estuaires et implantations humaines: De la préhistoire aux grandes invasions*. Paris: Éditions du Comité des travaux historiques et scientifiques, 241–52.

Raffles, H., and WinklerPrins, A. M. G. A. (2003) 'Further reflections of Amazonian environmental history: Transformations of rivers and streams'. *Latin American Research Review* 38 (3): 165–87.

Raftery, B. (1990) *Trackways through time: Archaeological investigations on Irish bog roads, 1985–1989.* Rush: Headline.

——(1994) *Pagan Celtic Ireland*. London: Thames & Hudson.

——(1996*a*) 'Catalogue of excavated toghers'. In B. Raftery (ed.), *Trackway excavations in the Mountdillon bogs, Co.Longford, 1985–1991*. Dublin: Crannóg Publication and Irish Archaeological Wetland Unit, 7–195.

——(1996*b*) 'Discussion of wooden artefacts'. In B. Raftery (ed.), *Trackway excavations in the Mountdillon bogs, Co.Longford, 1985–1991*. Dublin: Crannóg Publication and Irish Archaeological Wetland Unit, 263–89.

Raftery, B. (1996*c*) 'The Mountdillon toghers'. In B. Raftery (ed.), *Trackway excavations in the Mountdillon bogs, Co.Longford, 1985–1991*. Dublin: Crannóg Publication and Irish Archaeological Wetland Unit, 197–210.

——(1996*d*) *Trackway excavations in the Mountdillon bogs, Co.Longford, 1985–1991.* Dublin: Irish Archaeological Wetland Unit.

——(1996*e*) 'The wider context'. In B. Raftery (ed.), *Trackway excavations in the Mountdillon bogs, Co.Longford, 1985–1991*. Dublin: Crannóg Publication and Irish Archaeological Wetland Unit, 211–30.

Ramsar (2002) 'Guiding principles for taking into account the cultural values of wetlands for the effective management of sites. Wetlands: water, life, and culture: 8th Meeting of the Conference of the Contracting Parties to the Convention on Wetlands (Ramsar, Iran, 1971) Valencia, Spain, 18–26 November 2002. Resolution VIII.19'. Online pdf: <http://www.ramsar.org/pdf/res/key_res_viii_19_e.pdf>, accessed July 2011.

——(2005) 'Taking into account the cultural values of wetlands. Wetlands and water: supporting life, sustaining livelihoods: 9th Meeting of the Conference of the Contracting Parties to the Convention on Wetlands (Ramsar, Iran, 1971) Kampala, Uganda, 8–15 November 2005, Resolution IX.21'. Online pdf: <http://www.ramsar.org/pdf/res/key_res_ix_21_e.pdf>, accessed July 2011.

——(2007) 'The Ramsar 'Toolkit' (3rd edn.): The Ramsar handbooks for the wise use of wetlands'. Online pdf: <http://www.ramsar.org/pdf/lib/lib_handbooks2006_e01.pdf>, accessed July 2011.

——(2008) 'The Ramsar Strategic Plan 2009–2015'. Online pdf: <http://www.ramsar.org/pdf/key_strat_plan_2009_e.pdf>, accessed July 2011.

Ramseyer, D. (1988) *La Céramique néolithique d'Auvernier-La Saunerie (fouille 1964–1965).* Cahiers d'Archéologie Romande Auvernier 7. Lausanne: Bibliothèque Historique Vaudoise.

——(2001) 'La Suisse'. In B. J. Coles and A. Olivier (eds.), *The heritage management of wetlands in Europe*. Exeter: Europae Archaeologiae Consilium and WARP, 109–16.

——(2006) 'Protection d'un site archéologique sur la presqu'Île de Greng, Lac de Morat'. In D. Ramseyer and M.-J. Roulière-Lambert (eds.), *Archéologie et érosion—2: Zones humides en péril.* Lons-le-Saunier: Centre Jurassien du Patrimoine, 39–45.

——and Roulière-Lambert, M.-J. (eds.) (1996) *Archéologie et érosion: Mesures de protection pour la sauvegarde des sites lacustres et palustre.* Lons-Le-Saunier: Centre Jurassien Du Patrimoine.

————(eds.) (2006) *Archéologie et Érosion—2: Zones humides en péril.* Lons-Le-Saunier: Centre Jurassien Du Patrimoine.

Rankama, T. (2003) 'The colonisation of northernmost Finnish Lapland and the inland areas of Finnmark'. In L. Larsson, H. Kindgren, K. Knutsson, D. Loeffler, and A. Åkerlund (eds.), *Mesolithic on the move*. Oxford: Oxbow, 37–46.

Rapoport, A. (1969) *House form and culture.* Englewood Cliffs: Prentice-Hall.

Rappaport, R. (1971) 'The flow of energy in an agricultural society'. *Scientific American* 224 (3): 116–32.

——(1977) 'Ecology, adaptation and ills of functionalism'. *Michigan Discussion in Anthropology* 2: 138–90.

Rapport, D. J., and Whitford, W. G. (1999) 'How ecosystems respond to stress'. *BioScience* 49 (3): 193–203.

Rasmussen, M. (1995) 'Settlement structure and economic variation in the early Bronze Age'. *Journal of Danish Archaeology* 11: 87–107.

——and Adamsen, C. (1993) 'The Bronze Age. Settlement'. In S. Hvass and B. Storgaard (eds.), *Digging into the Past. 25 years of archaeology in Denmark*. Aarhus: Royal Society of Northern Antiquaries/Jutland Archaeological Society, 136–41.

——and Grønnow, B. (1999) 'The historical-experimental centre at Lejre: 30 years of experiments with the past'. In P. G. Stone and P. G. Planel (eds.), *The constructed past: Experimental archaeology, education, and the public*. London: Routledge, 136–45.

——Li, Y., Lindgren, S., Skou Pederson, J., Albrechtsen, A., Moltke, I., Metspalu, M., Kivisild, T., Gupta, R., Bertalan, M., Nielsen, K., Gilbert, M. T. P., Wang, Y., Raghavan, M., Campos, P. F., Munkholm Kamp, H., Wilson, A. S., Gledhill, A., Tridico, S., Bunce, M., Lorenzen, E. D., Binladen, J., Guo, X., Zhao, J., Zhang, X., Zhang, H., Chen, M., Orlando, L., Kristiansen, K., Bak, M., Tommerup, N., Bendixen, C., Pierre, T. L., Grønnow, B., Meldgaard, M., Andreasen, C., Fedorova, S. A., Osipova, L. P., Higham, T. F. G., Bronk Ramsey, C., Hansen, T. v. O., Nielsen, F. C., Crawford, M. H., Brunak, S., Sicheritz-Ponte´n, T., Villems, R., Nielsen, R., Krogh, A., Wang, J., and Willerslev, E. (2010) 'Ancient human genome sequence of an extinct Palaeo-Eskimo'. *Nature* 463: 757–62.

Rast-Eicher, A. (2008) *Textilien, Wolle, Schafe der Eisenzeit in der Schweiz.* Antiqua 44. Basel: Archäologie Schweiz.

Raushenbach, V. M. (1956) *Srednee Zauralye v Epokhu Neolita i Bronzy.* Moscow: Gosudarstvennoe Izdatelstvo Kulturno-Prosvetitelskoi Literatury.

Reese, D. S. (2005) 'Whale bones and shell purple-dye at Motya (western Sicily, Italy)'. *Oxford Journal of Archaeology* 24 (2): 107–14.

Reichert, A. (2000) 'Zur Rekonstruktion der 'Ötzi'-Schuhe'. *Experimentelle Archäologie* 2000: 69–76.

Reilly, E. (2005) 'Chapter 8: Coleoptera'. In M. Gowen, J. O'Neill, and M. Phillips (eds.), *The Lisheen Mine Archaeological Project 1996–8*. Dublin: Wordwell, 187–209.

——(2009) 'Insect remains from Lemanaghan, 1996–2001'. In J. Whittaker and E. Ocarroll (eds.), *Peatland excavations 1999–2000: Lemanaghan excavations*. Bray: Wordwell, 131–49.

Reimer, P. J., Baillie, M. G. L., Bard, E., Bayliss, A., Beck, J. W., Bertrand, C. J. H., Blackwell, P. G., Buck, C. E., Burr, G., Cutler, K. B., Damon, P. E., Edwards, R. L., Fairbanks, R. G., Friedrich, M., Guilderson, T. P., Hogg, A. G., Hughen, K. A., Kromer, B., McCormac, F. G., Manning, S., Bronk Ramsey, C., Reimer, R. W., Remmele, S., Southon, J. R., Stuiver, M., Talamo, S., Taylor, F. W., van der Plicht, J., and Weyhenmeyer, C. E. (2004) 'IntCal04 terrestrial radiocarbon age calibration, 0–26 kyr BP'. *Radiocarbon* 46 (3): 102–58.

————————Blackwell, P. G., Bronk Ramsey, C., Buck, C. E., Burr, G. S., Edwards, R. L., Friedrich, M., Grootes, P. M., Guilderson, T. P., Hajdas, I., Heaton, T. J., Hogg, A. G., Hughen, K. A., Kaiser, K. F., Kromer, B., McCormac, F. G., Manning, S. W., Reimer, R. W., Richards, D. A., Southon, J. R., Talamo, S., Turney, C. S. M., van der Plicht, J. and Weyhenmeyer, C. E. (2009) 'IntCal09 and Marine09

radiocarbon age calibration curves, 0–50,000 years cal BP'. *Radiocarbon* 51 (4): 1111–50.

Reinerth, H. (1932) *Das Pfahlbaudorf Sipplingen. Ergebnisse der Ausgrabungen des Bodenseegeschichtsvereins 1929–30.* Leipzig: Curt Kabitsch.

Rentzel, P., and Narten, G. (2000) 'Zur Entstehung von Gehniveaus in sandig-lehmigen Ablagerungen. Experimente und archäologische Befunde'. *Archäologische Bodenforschung des Kantons Basel-Stadt*: 107–27.

Rentzhog, S. (2007) *Open-air museums, the history and future of a visionary idea.* Kristianstad: Kristianstads Bokrtyckeri.

Retallack, G. J. (1984) 'Completeness of the rock and fossil record: Some estimates using fossil soils'. *Palaeobiology* 10: 59–78.

Reynolds, P. J. (1967) 'Experiment in Iron Age agriculture'. *Transactions of the Bristol and Gloucestershire Archaeological Society* 86: 60–73.

——(1976) 'Experimental archaeology and the Butser ancient farm project'. *Rescue News* 11: 7–8.

——(1977) 'Slash and burn experiment from the Butser Ancient Farm project in Hampshire'. *The Archaeological Journal* 134: 307–18.

——(1979) *Iron Age farm—the Butser experiment.* London: British Museum.

——(1999) 'Buster ancient farm: Hampshire UK'. In P. G. Stone and P. G. Planel (eds.), *The constructed past: Experimental archaeology, education, and the public.* London: Routledge, 124–35.

Rieck, F. (1999) 'The Nydam sacred site, Denmark'. In B. J. Coles, J. M. Coles, and M. S. Jørgensen (eds.), *Bog bodies, sacred sites and wetland archaeology*. Exeter: Wetland Archaeology Research Project, 209–16.

——(2003) 'Denmark'. In U. Djerw and J. Rönnby (eds.), *Treasures of the Baltic Sea: A hidden wealth of culture.* Stockholm: Swedish Maritime Museum, 54–67.

Rigert, E. (1999) 'Fundberichte 1998'. *Jahrbuch der Schweizerischen Gesellschaft für Ur- und Frühgeschichte* 82: 250–90.

——(2001) *A7-Ausfahrt Archäologie: Prospektion und Grabungen im Abschnitt Schwaderloh-Landesgrenze.* Frauenfeld: Amt für Archäologie des Kantons Thurgau.

Rimantienė, R. (1992*a*) 'Neolithic hunter-gatherers at Šventoji in Lithuania'. *Antiquity* 66: 367–76.

——(1992*b*) 'The Neolithic in the Eastern Baltic'. *Journal of World Prehistory* 6: 97–143.

——(1998) 'The first Narva Culture farmers in Lithuania'. In M. Zvelebil, L. Domańska, and R. Dennell (eds.), *Harvesting the sea, farming the forest: The emergence of Neolithic societies in the Baltic Region*. Sheffield: Sheffield Academic Press, 213–18.

Ringer, R. J. (2006) 'Atherley Narrows fish weirs'. In R. Grenier, D. Nutley, and I. Cochran (eds.), *Underwater Cultural Heritage at risk: Managing natural and human impacts*. Paris: International Council on Monuments and Sites, 44–5.

Rippon, S. (1997) *The Severn Estuary: Landscape evolution and wetland reclamation.* London: Leicester University Press.

——(2000) *The transformation of coastal wetlands.* London: British Academy.

——(2001*a*) 'Adaptation to changing environment: The response of marshland communities to the late medieval "crisis"'. *Journal of Wetland Archaeology* 1: 15–39.

——(2001*b*) 'The historic landscapes of the Severn Estuary Levels'. In S. Rippon (ed.), *Estuarine archaeology: The Severnand beyond*. Exeter: Severn Estuary Levels Research Committee, 145–61.

Roberts, A. (1994) 'Cultural land marks: The Milingimbi mounds'. In M. Sullivan, S. Brockwell, and A. Webb (eds.), *Archaeology in the North: Proceedings of the 1993 Australian Archaeological Association Conference*. Darwin: North Australia Research Unit, Australian University, 176–87.

Robertshaw, P. T. (1987) 'The prehistory of the Upper Nile Basin'. *Journal of African History* 28: 177–89.

Rockman, M. (2001) 'The landscape learning process in historical perspective'. In S. T. Gillespie and C. de Mille (eds.), *31st Annual Chacmool Conference Proceedings*. Calgary: Archaeological Association of the University of Calgary, 493–509.

——(2003) 'Knowledge and learning in the archaeology of colonization'. In M. Rockman and J. Steele (eds.), *Colonization of unfamiliar landscapes: The archaeology of adaptation*. London: Routledge, 3–24.

Roio, M. (2007) 'New interpretations of settlement remains in Lake Valgjärv of Koorküla, Estonia'. *Journal of Wetland Archaeology* 7: 23–32.

Roosevelt, A. (1999) 'Twelve thousand years of human-environment interaction in the Amazon floodplain'. In C. Padoch, M. Ayres, M. Pinedo-Vasquez, and A. Henderson (eds.), *Varzea: Diversity, development, and conservation in Amazonia's whitewater floodplains*. New York: Botanical Garden Press, 371–91.

Rösch, M. (1996) 'New approaches to prehistoric land-use reconstruction in southwestern Germany'. *Vegetation History and Archaeobotany* 5 (1–2): 65–79.

——(2000) 'Anthropogener Landschaftswandel in Mitteleuropa während des Neolithikums—Beobachtungen und Überlegungen zum Verlauf und möglichen Ursachen'. *Germania* 78: 293–318.

——Ehrmann, O., Kury, B., Bogenrieder, A., Herrmann, L., and Schier, W. (2008) 'Spätneolithische Landnutzung im nördlichen Alpenvorland: Beobachtungen—Hypothesen—Experimente'. In W. Dörfler and J. Müller (eds.), *Umwelt—Wirtschaft—Siedlungen im dritten vorchristlichen Jahrtausend Mitteleuropas und Südskandinaviens*. Neumünster: Wachholtz, 301–15.

————Herrmann, L., Schulz, E., Bogenrieder, A., Goldammer, J. G., Hall, M., Page, H. and Schier, W. (2002) 'An experimental approach to Neolithic shifting cultivation'. *Vegetation History and Archaeobotany* 11: 143–54.

Rosenfeld, R. A. (2003) 'Performance practice, experimental archaeology, and the problem of the respectability of results'. In T. J. McGee (ed.), *Improvisation in the Arts of the Middle Ages and Renaissance*. Early Drama, Art, and Music Monograph Series. Kalamazoo: Chilton Books, 3071–97.

Rostain, S. (2010) 'Pre-Columbian earthworks in coastal Amazonia'. *Diversity* 2: 331–52.

Roth Heege, E. (2007) 'Naturwissenschaftliche Datierungen'. In B. Röder and R. Huber (eds.), *Archäologie in 'Steinhausen Sennwei'(Kanton Zug): Ergebnisse der Untersuchungen von 1942 bis 2000*. Basel: Archäologie Schweiz, 181–97.

Rubat Borel, F. (2006*a*) 'Il Bronzo Finale nell'estremo Nord-Ovest italiano: il gruppo Pont-Valperga'. *Rivista di Scienze Preistoriche* LVI: 429–82.

——(2006*b*) '"Quasi al vertice d'Italia": itinerari protostorici lungo la Dora Baltea tra la pianura piemontese e i valichi valdostani'. In Projet Interreg IIIA (ed.), *Alpis*

Graia: Archéologie sans frontières au col du Petit-Saint-Bernard. Quart: Musumeci S.p.A., 259–68.

Ruhl, D. L., and Purdy, B. A. (2005) 'One hundred-one canoes on the shore—3-5000 year old canoes from Newnans Lake, Florida'. *Journal of Wetland Archaeology* 5: 111–27.

Ruoff, U. (1981) 'Die Ufersiedlungen an Zürich- und Greifensee'. *Helvetica Archaeologica* 45/8: 19–61.

——(1990) 'Die Ufersiedlungen am Zürichsee'. In Schweizerisches Landesmuseum (ed.) *Die ersten Bauern*. 145-59. Zurich: Schweizerisches Landesmuseum, 145–59.

——(2004) 'Lake-dwelling studies in Switzerland since Meilen 1854'. In F. Menotti (ed.), *Living on the lake in prehistoric Europe: 150 years of lake-dwelling research*. London: Routledge, 9–21.

——(2006) '150 Jahre nach der Entdeckung der Entdeckung der Pfahlbauten'. In A. Hafner, U. Niffeler, and U. Ruoff (eds.), *Die neue Sicht—Unterwasserarchäologie und Geschichtsbild*. 14-23. Basel: Archäologie Schweiz, 14–23.

Russell, N. J., Bonsall, C., and Sutherland, D. G. (1995) 'The exploitation of marine molluscs in the Mesolithic of western Scotland: Evidence from Ulva Cave, Inner Hebrides'. In A. Fischer (ed.), *Man and sea in the Mesolithic: Coastal settlement above and below present sea level*. Oxford: Oxbow, 273–88.

Rycyhner Faraggi, A. M. (1993) *Hauterive-Champréveyres 9. Métal et parure au Bronze final*. Neuchâtel: Musée cantonale d'archéologie.

Ryzhov, S. N. (2008) 'The kitchen ceramic of the Tripolye settlement of Talianki'. In A. G. Korvin-Piotrovskiy and F. Menotti (eds.), *Tripolye culture in Ukraine: The giant-settlement of Talianki*. Kiev: Korvin, 140–51.

Sadori, L., Giraudi, C., Petitti, P., and Ramrath, A. (2004) 'Human impact at Lago di Mezzano (central Italy) during the Bronze Age: a multidisciplinary approach'. *Quaternary International* 113: 5–17.

Saino, H. (ed.) (1992) *Tomizawa iseki kyusekkijidai henn dai 30 ji chousa houkoku, sendaishi bunkazai chousa houkoku (The 30th Research Report II on Tomizawa Site (Paleolithic))*. Sendai City: Cultural Research Centre.

Salvadei, L., Santandrea, L., and Manzi, G. (1997) 'Tra biologia e cultura: i resti scheletrici incinerati dalle necropoli delle terramare emiliane'. In M. Bernabó Brea, A. Cardarelli, and M. Cremaschi (eds.), *Le terramare: La più antica civiltà padana*. Milan: Electa.

Sampson, C. G. (1985) *Nightfire Island: Later Holocene lakemarsh adaptations on the western edge of the Great Basin*. Anthropological Papers 33. Eugene: University of Oregon.

Samuels, S. R. (1983) 'Spatial analysis of Ozette house floor deposits'. *Laboratory of anthropology*. Pullman: Washington State University .

Sands, R. (1997) *Prehistoric woodworking: The analysis and interpretation of Bronze Age and Iron Age toolmarks*. London: Archetype.

Sandström, M., Jalilehvand, F., Persson, I., Damian, E., Gelius, U., Hall-Roth, I., Dal, L., Vicki, R., and Ian, G. (2003) 'The sulphur threat to marine archaeological artefacts: Acid and iron removal from the Vasa'. In J. H. Townsend, K. Eremin, and A. Adriaens (eds.), *Conservation science 2002*. London: Archetype, 79–87.

Santos, G. M., Alexandre, A., Coe, H. H. G., Reyeson, P. E., Southon, J. R., and De Carvalho, C. N. (2009) 'The phytolith ^{14}C puzzle: a tale of background determinations and accuracy tests'. *Radiocarbon* 52 (1): 113–28.

Sarauw, T. (2008) 'On the outskirts of the European Bell Beaker phenomenon. The settlement of Bejsebakken and the social organisation of Late Neolithic societies'. In W. Dörfler and J. Müller (eds.), *Umwelt—Wirtschaft—Siedlungen im dritten vorchristlichen Jahrtausend Mitteleuropas und Südskandinaviens*. Neumünster: Wachholtz, 83–125.

Saraydar, S. C. (2008) *Replicating the past*. Long Grove: Waveland.

Saunders, J. W., Mandel, R. D., Saucier, R. T., Allen, E. T., Hallmark, C. T., Johnson, J. K., Jackson, E. H., Allen, C. M., Stringer, G. L., Frink, D. S., Feathers, J. K., Williams, S., Gremillion, K. J., Vidrine, M. F., and Jones, R. (1997) 'A mound complex in Louisiana at 5400—5000 years Before Present'. *Science* 277: 1796–9.

Saunders, L. P. (1972) 'Osteology of the Republic Groves Site'. Boca Raton: Florida Atlantic University.

Scales, R. (2007) 'Footprint-tracks of people and animals'. In M. Bell (ed.), *Prehistoric coastal communities: The Mesolithic in western Britain*. York: Council for British Archaeology, 139–59.

Scarre, C. (1989) 'Review of J. M. Coles and A. Lawson (eds.) [1987] European Wetlands in Prehistory [Clarendon Press]'. *Proceedings of the Prehistoric Society* 55: 274–5.

Schaaf, M., and Thurow, J. (1994) 'A fast and easy method to derive highest-resolution time series datasets from drillcores and rock samples'. *Sedimentary Geology* 94: 1–10.

Schaan, D. (2010) 'Long-term human induced impacts on Marajó island landscapes, Amazon estuary'. *Diversity* 2 (2): 182–206.

Schadla-Hall, T. (2004) 'The comforts of unreason: The importance and relevance of alternative archaeology'. In N. Merriman (ed.), *Public archaeology*. London: Routledge, 255–71.

Schaub, M., Kaiser, K. F., Frank, D. C., Büntgen, U., Kromer, B. and Talamo, S. (2008) 'Environmental change during the Allerød and Younger Dryas reconstructed from Swiss tree-ring data'. *Boreas* 37: 74–86.

Schettler, G., Liu, Q., Mingram, J., Stebich, M., and Dulski, P. (2006) 'East-Asian monsoon variability between 15000 and 2000 cal. yr BP recorded in varved sediments of Lake Sihailongwan (northeastern China, Long Gang volcanic field)'. *The Holocene* 16 (8): 1043–957.

Schibler, J. (2001*a*) 'Experimental production of Neolithic bone and antler tools'. In A. M. Choyke and L. Bartosiewicz (eds.), *Crafting bone: Skeletal technologies through time and space*. Oxford: Archaeopress, 49–60.

——(2001*b*) 'Red deer antler: Exploitation and raw material management in Neolithic lake-dwelling sites from Zurich, Switzerland'. In H. Buitenhuis and W. Prummel (eds.), *Animals and man in the past*. Groningen: ARC, 82–94.

——(2004) 'Bones as a key for reconstructing the environment, nutrition and economy of the lake-dwelling societies'. In F. Menotti (ed.), *Living on the lake in prehistoric Europe: 150 years of lake-dwelling research*. London: Routledge, 144–61.

SCHIBLER, J. (2006) 'The economy and environment of the 4th and 3rd millennia BC in the northern Alpine foreland based on studies of animal bones'. *Environmental Archaeology* 11 (1): 49–64.

——(2008) 'Die wirtschaftliche Bedeutung der Viehzucht während des 3. Jahrtausends v. Chr. aufgrund der Tierknochenfunde der Fundstellen im Schweizer Alpenvorland'. In W. Dörfler and J. Müller (eds.), *Umwelt—Wirtschaft—Siedlungen im dritten vorchristlichen Jahrtausend Mitteleuropas und Südskandinaviens*. Neumünster: Wachholtz, 379–91.

——JACOMET, S., HÜSTER-PLOGMANN, H. and BROMBACHER, C. (1997*a*) 'Economic crash in the 37th and 36th century BC cal in Neolithic lake shore sites in Switzerland'. *Anthropozoologica* 25–6: 553–70.

——HÜSTER-PLOGMANN, H., JACOMET, S., BROMBACHER, C., GROSS-KLEE, E., and RAST-EICHER, A. (eds.) (1997*b*) *Ökonomie und Ökologie neolithischer und bronzezeitlicher Ufersiedlungen am Zürichsee.* Zurich: Direktion der öffentlichen Bauten des Kantons Zürich.

——MARTI-GRÄDEL, E., DESCHLER-ERB, S., and DOPPLER, T. (2010) 'Hafted points and their functional interpretation on the basis of their horizontal distribution at the Neolithic site of Arbon Bleiche 3 (3384–3370 BC), Switzerland'. In A. Legrand-Pineau, I. Sidéra, N. Buc, E. David, and V. Scheinsohn (eds.), *Ancient and modern bone artefacts from America to Russia—cultural, technological and functional signature*. Oxford: Archaeopress, 249–54.

SCHIFFER, M. B. (1987) *Formation processes of the archaeological record.* Albuquerque: University of New Mexico Press.

——SULLIVAN, A. P., and KLINGER, T. C. (1978) 'The design of archaeological surveys'. *World Archaeology* 10 (1): 1–28.

SCHILLING, H. (2003) 'Early Mesolithic settlement patterns in Holmegårds Bog on South Zealand, Denmark'. In L. Larsson, H. Kindgren, K. Knutsson, D. Loeffler, and A. Åkerlund (eds.), *Mesolithic on the move*. Oxford: Oxbow, 351–8.

SCHINDELHOLZ, E., BLANCHETTE, R., COOK, C., DREWS, M., HAND, S., and SEIFERT, B. (2009) 'An evaluation of supercritical drying and PEG/freeze drying of waterlogged archaeological wood'. In K. Straetkvern and D. J. Huisman (eds.), *Proceedings of the 10th ICOM Group on Wet Organic Archaeological Materials Conference, Amsterdam 2007*. Amersfoort: ICOM Committee for Conservation Working Group on Wet Organic Archaeological Materials, 399–416.

SCHINKEL, C. (1998) 'Unsettled settlement, occupation remains from the Bronze Age and the Iron Age at Oss-Ussen: The 1976–1986 excavations'. *Analecta Praehistorica Leidensia* 30: 5–306.

SCHLEIFER, N., WELLER, A., SCHNEIDER, S., and JUNGE, A. (2002) 'Investigation of a Bronze Age plankway by spectral induced polarization'. *Archaeological Prospection* 9: 243–53.

SCHLENKER, R., and BICK, A. (2007) *Steinzeit. Leben wie vor 5000 Jahren.* Stuttgart: Theiss.

SCHLICHTHERLE, H. (1997*a*) 'Der Federsee, das fundreichste Moor der Pfahlbauforschung'. In H. Schlichtherle (ed.), *Pfahlbauten rund um die Alpen*. Stuttgart: Konrad Theiss, 91–9.

——(1997*b*) 'Pfahlbauten rund um die Alpen'. In H. Schlichtherle (ed.), *Pfahlbauten rund um die Alpen*. Stuttgart: Konrad Theiss, 7–14.

——(2001) 'Schutz und Management archäologischer Denkmale im Bodensee und Federsee'. In B. J. Coles and A. Olivier (eds.), *The heritage management of wetlands in Europe*, Exeter: Europae Archaeologiae Consilium and WARP, 125–32.

——(2002) 'Prähistorische Siedlungen, Bohlenwege und Fischfanganlagen. Fortschritte der archäologischen Federseeforschung'. *Denkmalpflege in Baden-Württemberg* 31: 115–21.

——(2004) 'Grosse Häuser—Kleine Häuser'. In Landesdenkmalamt Baden-Württemberg (ed.), *Ökonmischer und ökologischer Wandel am vorgeschichtlichen Federsee*. Freiburg: Janus, 13–56.

——(2006*a*) 'Chemins, roues et chariots: innovation de la fin du Néolithique dans le sud-ouest de l'Allemagne'. In P. Pétrequin, R.-M. Arbogast, A.-M. Pétrequin, S. Van Willigen, and M. Bailly (eds.), *Premiers chariots, premiers araires: La diffusion de la traction animale en Europe pendant le IV*^e^ *et III*^e^ *millénaires avant notre ère*. Paris: CNRS, 165–78.

——(2006*b*) 'Kulthäuser in neolithischen Pfahlbausiedlungen des Bodensees'. In A. Hafner, U. Niffeler, and U. Ruoff (eds.), *Die neue Sicht—Unterwasserarchäologie und Geschichtsbild*. Basel: Archäologie Schweiz, 122–45.

——(2009) 'Eine neue Siedlungskammer im westlichen Federseeried und ihre Bedeutung für das Verständnis neolithischer Siedelsysteme'. In J. Biel, J. Heiligmann, and D. Krausse (eds.), *Landesarchäologie: Festschrift für Dieter Planck zum 65. Geburtstag*. Stuttgart: Forschungen und Berichte zur Vor- und Frühgeschichte in Baden-Württemberg, 61–86.

——and Strobel, M. (1999) *Archäologie und Naturschutz im Federseemoor.* Stuttgart: Landesdenkmalamt Baden-Württemberg.

——and Wahlster, B. (1986) *Archäologie in Seen und Mooren.* Stuttgart: Konrad Theiss.

——Bleicher, N., Dufraisse, A., Kieselbach, P., Maier, U., Schmidt, E., Stephan, E., and Vogt, R. (2010) 'Bad Buchau-Torwiesen II: Baustrukturen und Siedlungsabfälle als Indizien der Sozialstruktur und Wirtschaftsweise einer endneolithischen Siedlung am Federsee'. In E. Claßen, T. Doppler, and B. Ramminger (eds.), *Familie—Verwandtschaft—Sozialstrukturen: Sozialarchäologische Forschungen zu neolithischen Befunden*. Kerpen-Loogh: Welt & Erde, 1–20.

Schlitzer, U. (2006) 'Eisenzeitliche Baubefunde Nordostspitze Roseninsel'. *Bayerische Gesellschaft für Unterwasserarchäologie (Jahresberichte)* 7: 3.

——(2009) 'Seeufersiedlungen in Bayern. Die Roseninsel im Starnberger See und das Problem der bayerischen Lücke'. In J. M. Bagley and C. Eggl (eds.), *Alpen, Kult und Eisenzeit*. Rahden: Studia honoraria, 493–504.

Schlumbaum, A., Neuhaus, J.-M. and Jacomet, S. (1998) 'Coexistence of tetraploid and hexaploid naked wheat in a Neolithic lake-dwelling of Central Europe: evidence from morphology and ancient DNA'. *Journal of Archaeological Science* 25: 1111–18.

——Tensen, M., and Jaenicke-Després, V. (2008) 'Ancient plant DNA in Archaeobotany'. *Vegetation History and Archaeobotany* 17: 233–44.

——Campos, P. F., Volken, S., Volken, M., Hafner, A., and Schibler, J. (2010) 'Ancient DNA, a Neolithic legging from the Swiss Alps and the early history of goat'. *Journal of Archaeological Science* online.

Schmid, P. (2002) 'Feddersen Wierde, Lower Saxony, Germany'. In C. E. Orser (ed.), *Encyclopedia of historical archaeology*. London: Routledge, 200–3.

——and Schuster, J. (1999) 'Dating the early layers of the *Wurt*-Settlement Feddersen Wierde'. In H. Sarfatij, W. J. H. Verwers, and P. J. Woltering (eds.), *In discussion with the past*. Amersfoort: Foundation for Promoting Archaeology, 97–106.

Schmid, W. (1995) 'Die frühen Ausgrabungen auf der Roseninsel im Starnberger See und der Beginn der Unterwasserarchäologie in Bayern'. In Landesdenkmalamt Baden-Württemberg (ed.), *Archäologie unter Wasser 1*. Stuttgart: Landesdenkmalamt Baden-Württemberg, 64–70.

——Beer, H., and Schlitzer, U. (2009) *Die archäologische Erforschung der Roseninsel im Starnberger See*. Bonn: Bayerisches Landesamtes Denkmalpflege Bodendenkmalpflege.

Schmidt, H. (2000) *Archäologische Denkmäler in Deutschland. Rekonstruirt und wieder aufgebaut*. Stuttgart: Theiss.

Schmölcke, U. (2004) 'Neue archäozoologische Untersuchungen zur Mecklenburger Bucht und um Jasmunder Bodden'. *Bodendenkmalpflege in Mecklenburg-Vorpommern* 52: 145–54.

——(2006) 'Meeresspiegelanstieg—Landschaftswandel—Kulturwandel. Der südwestliche Ostseeraum zwischen 8800 und 4000 v. Chr.'. In D. Gronenborn (ed.), *Klimaveränderungen und Kulturwandel in neolithischen Gesellschaften Mitteleuropas, 6700–2200. RGZM-Tagungen 1*. Mainz: RGZM Publishing House, 189–202.

Schöbel, G. (1995) 'Tauchuntersuchungen in den Siedlungen der Spätbronzezeit am Bodensee'. In Landesdenkmalamt Baden-Württemberg (ed.), *Archäologie unter Wasser 1*. Stuttgart: Landesdenkmalamt Baden-Württemberg, 51–7.

——(1997) 'Pfahlbaumuseen und Pfahlbausammlungen'. In H. Schlichtherle (ed.), *Pfahlbauten rund um die Alpen*. Stuttgart: Konrad Theiss, 115–23.

——(1999) 'Das neue "Steinzeithaus" im Freilichtmuseum Unteruhldingen'. *Plattform* 7/8: 82–91.

——(2001) 'Vom Baum zum Einbaum—ein archäologisches Experiment im Pfahlbaumuseum Unteruhldingen'. *Plattform* 9–10: 97–106.

——(ed.) (2002) *Archaeological Open-air Museums in Europe. EXARC*. Markdorf: Zanker.

——(2003*a*) 'Fünf neue Häuser im Pfahlbaumuseum'. *Plattform* 11–12: 4–35.

——(2003*b*) *Lake-dwelling Museum of Unteruhldingen, Museum Guide*. Markdorf: Zanker.

——(2004*a*) 'Lake-dwelling museums: Academic research and public information'. In F. Menotti (ed.), *Living on the lake in prehistoric Europe: 150 years of lake-dwelling research*: 221–36. London: Routledge.

Schöbel, G. (2004*b*) 'On the responsibilities of accurately interpreting prehistoric life in full scale'. *EuroREA* 1: 150–60.

——(2005) 'Geschichte der Ausstellungskonzepte im Pfahlbaumuseum Unteruhldingen'. In P. Della Casa and M. Trachsel (eds.), *WES'04: Wetland economies and societies*. Zurich: Chronos, 283–96.

——(2006*a*) 'Das Delphi-Projekt'. *Plattform* 13–14: 30–5.

——(2006*b*) 'Museen zum Anfassen, Einrichtungen mit "Living History" in Deutschland und Europa'. In E. Keefer (ed.), *Lebendige Vergangenheit vom archäologischen Experiment zur Zeitreise*. Stuttgart: Konrad Theiss.

SCHÖNFELD, G. (1992) 'Ein Wohnstallhaus aus der jungneolithschen Talbodensiedlung von Pestenacker'. *Das archäologische Jahr in Bayern* 6: 44–55.

——(2009) 'Die altheimzeitliche Feuchtbodensiedlung von Pestenacker'. *Bericht der Bayerischen Bodendenkmalpflege* 50: 137–56.

SCHRENK, S. (2004) *Textilien des Mittelmeerraumes aus spätantiker bis frühislamischer Zeit.* Riggisberg: Abegg-Stiftung.

SCHWEINGRUBER, F. H. (2001) *Dendroökologische Holzanatomie. Anatomische Grundlagen der Dendrochronologie.* Berne: Haupt.

SEARS, W. H. (1982) *Fort Center: an archaeological site in the Lake Okeechobee Basin.* Gainesville: University Press of Florida.

SEDLMEIER, J. (2003) 'Neue Erkenntnisse zum Neolithikum in der Nordwestschweiz'. *Archäologie Schweiz* 26 (4): 2–14.

SELIRAND, J. (1986) 'Neue Funde aus dem See Valgjärv. Eesti NSV Teaduste Akadeemia Toimetised'. *Ühiskonnateadused* 4: 252–3.

SERIKOV, Y. B. (1992) 'Koksharovsko-Yurinskaya Peat Camp in the Middle Trans-Urals'. *Rossiiskaya Arkheologiya* 4: 131–47.

SHACKLEY, M. L. (1978) 'The behaviour of artefacts as sedimentary particles in a fluviatile environment'. *Archaeometry* 20: 5–61.

SHANKS, M., and HODDER, I. (1998) 'Processual, postprocessual & interpretive archaeologies'. In D. S. Whitley (ed.), *Reader in Archaeological Theory: Post-Processual & Cognitive Approaches*. New York: Routledge, 69–95.

——and Tilley, C. (1987) *Social theory and archaeology.* Cambridge: Polity.

SHAWCROSS, W. (1976) 'Kauri Point Swamp: The ethnographic interpretation of a prehistoric site'. In G. d. G. Sieveking, I. H. Longworth, and K. E. Wilson (eds.), *Problems in economic and social archaeology*. London: Duckworth, 277–305.

SHENNAN, I., and ANDREWS, J. (eds.) (2000) *Holocene land-ocean interaction and environmental change around the North Sea*. London: Geological Society.

SHERIDAN, T. (1988) *Where the dove calls: the political ecology of a peasant corporate community.* Tucson: University of Arizona Press.

SHERRATT, A. G. (1995) 'Instruments of conversation: The role of megaliths in the Mesolithic–Neolithic transition in north-west Europe'. *Oxford Journal of Archaeology* 14 (3): 245–60.

SHIMADA, I. (2005) 'Experimental archaeology'. In H. D. G. Maschner and C. Chippindale (eds.), *Handbook of archaeological methods*. Lanham: AltaMira, 603–42.

SIEMEN, P. (2008) 'Settlements from the 3rd millennium BC in Southwest Jutland'. In W. Dörfler and J. Müller (eds.), *Umwelt—Wirtschaft—Siedlungen im dritten vorchristlichen Jahrtausend Mitteleuropas und Südskandinaviens*. Neumünster: Wachholtz. 67–82.

SIEMENS, A. H. (1998) *A favored place.* Austin: University of Texas Press.

——HEBDA, R. J., HERNANDEZ, M. N., PIPERNO, D. R., STEIN, J., and BAEZ, M. G. Z. (1988) 'Evidence for a cultivar and a chronology from patterned wetlands in Central Veracruz, Mexico'. *Science* 242 (4875): 105–7.

SILVA, J. A., ERIKSEN, S., and OMBE, Z. A. (2010) 'Double exposure in Mozambique's Limpopo River Basin'. *The Geographical Journal* 176 (1): 6–24.

SIKORA, L. J., and KEENEY, D. R. (1983) 'Further aspects of soil chemistry under anaerobic conditions'. In A. J. P. Gore (ed.), *Ecosystems of the world 4A, mires: Swamps, bog, fen, and moor*. Amsterdam: Elsevier Scientific, 247–56.

SIMMONS, D. R. (1994) *Whakairo: Maori tribal art.* Oxford: Oxford University Press.

SIMON, C., LANGENEGGER, E., and CUENI, A. (1995) 'Anthropologie'. In W. Stöckli, U. Niffeler, and E. Gross-Klee (eds.), *Die Schweiz vom Paläolithikum bis zum frühen Mittelalter II (Neolithikum).* Basel: Schweizerische Gesellschaft für Ur- und Frühgeschichte, 259–74.

SIVAN, D., ELIYAHU, D., and RABAN, A. (2004) 'Late Pleistocene to Holocene wetlands now covered by sand along the Carmel coast, Israel, and their relation to human settlement: An example from Dor'. *Journal of Coastal Research* 20 (4): 1035–48.

SIX, S., PAULISSEN, E., VAN THUYNE, T., LAMBRECHTS, J., VERMOERE, M., DE LAET, V., and WAELKENS, M. (2008) 'Late Holocene sediment characteristics and sediment accumulation in the marsh of Gravgaz: Evidence for abrupt environmental changes'. In P. Degryse and M. Waelkens (eds.), *Sagalassos VI: Geo-and bio-archaeology at Sagalassos and its territory*. Leuven: Leuven University Press, 189–208.

SKAARUP, J. (1995) 'Stone Age burials in boats'. In O. Crumlin-Pedersen and B. Munch Thye (eds.), *The ship as symbol in prehistoric and Medieval Scandinavia*. Copenhagen: Danish National Museum, 51–8.

SKIDMORE, P. (2000) 'Diptera analysis'. In A. Crone (ed.), *The history of a Scottish lowland crannog: Excavations at Buiston, Ayrshire*. Monograph 4. Edinburgh: Scottish Trust for Archaeological Research, 252–4.

SLOCOMBE, A. (2001) *An archaeological investigation of wetland site, PO6/82, Kaikohe.* Whangarei: Department of Conservation, Northland Conservancy.

SLOGGET, R. (2009) 'Expanding the conservation canon: Assessing cross-cultural and interdisciplinary collaborations in conservation'. *Studies in Conservation* 54 (3): 170–83.

SLUYTER, A. (1994) 'Intensive wetland agriculture in Mesoamerca: Space, time and form'. *Annals of the Association of American Geographer* 84 (4): 557–84.

SMIT, A. (2004) 'Monitoring the burial environment of terrestrial wet archaeological sites in the Netherlands'. *Conservation and management of archaeological sites* 6 (3–4): 325–32.

SMITH, D. N., OSBORNE, P. J., and BARRETT, J. (2000) 'Beetles as indicators of past environments and human activity at Goldcliff'. In M. Bell, A. Caseldine, and H. Neumann (eds.), *Prehistoric intertidal archaeology in the Welsh Severn Estuary.* Research Report 120. York: Council for British Archaeology, 245–61.

SMITH, M. E. (2003) *The Aztecs.* Malden: Blackwell.

SMITH, R. J. (2005) 'The preservation and degradation of wood in wetland archaeological and landfill sites'. Unpublished PhD thesis, University of Hull.

SMITH, W. C. (2003) *Archaeological conservation using polymers: Practical applications for organic artifact stabilization.* Texas: Texas A & M University Press.

SOMMER, U. (2002) *'Roh und mangelhaft sind Ihre Gerätschaften': Ideologische Botschaften archäologischer Darstellungen.* Zug: Kantonales Museum für Urgeschichte.

SONNEBURG, E. P., and BOYCE, J. I. (2008) 'Data-fused digital bathymetry and side-scan sonar as a base for archaeological inventory of submerged landscapes in the Rideau Canal, Ontario, Canada'. *Geoarchaeology* 23 (5): 654–74.

Sørensen, B., and Gregory, D. (1998) '*In situ* preservation of artefacts in Nydam Mose'. In W. Mouray and L. Robbiola (eds.), *Metal 98: Proceedings of the International Conference of Metal Conservation*. London: James & James, 94–8.

Sormaz, T. (2004) 'Absolute Datierung durch Dendrochronologie und C^{14}-Analysen'. In S. Jacomet, U. Leuzinger, and J. Schibler (eds.), *Die jungsteinzeitliche Seeufersiedlung Arbon-Bleiche 3*. Frauenfeld: Veröffentlichung des Amtes für Archäologie des Kantons Thurgau, 105–11.

Spangenberg, J. E. (2004) 'Food residues: chemistry'. In S. Jacomet, U. Leuzinger, and J. Schibler (eds.), *Die jungsteinzeitliche Seeufersiedlung Arbon-Bleiche 3*. Frauenfeld: Veröffentlichung des Amtes für Archäologie des Kantons Thurgau, 284–93.

Speck, J. (1981) 'Pfahlbauten: Dichtung oder Wahrheit? Ein Querschitt durch 125 Jahre Forschungsgeschichte'. *Helvetia Archaeologica* 45/48: 98–138.

——(1990*a*) 'Zur Geschichte der Pfahlbauforschung. Ausstellungskatalog'. In Schweizerisches Landesmuseum (ed.), *Die ersten Bauern*. Zurich: Schweizerisches Landesmuseum Zürich, 9–20.

——(1990*b*) 'Zur Siedlungsgeschichte des Wauwilermooses'. In Schweizerisches Landesmuseum (ed.), *Die ersten Bauern*. Zurich: Schweizerisches Landesmuseum, 255–70.

Spriggs, M. J. T. (1990) 'Why irrigation matters in Pacific prehistory'. In D. E. Yen and J. M. J. Mummery (eds.), *Pacific production systems. Approaches to economic prehistory*. Canberra: Australian National University, 174–89.

Spurrell, F. C. J. (1892) 'Notes on early sickles'. *Archaeological Journal* 49: 53–69.

Staff, R. A., Bronk Ramsey, C., and Nakagawa, T. (2010) 'A re-analysis of the Lake Suigetsu terrestrial radiocarbon calibration dataset'. *Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms* 268 (7–8): 960–65.

Starkov, V. F. (1980) *Mezolit i Neolit Lesnogo Zauralya.* Moscow: Nauka.

Steensberg, A. (1943) *Ancient harvesting implements.* Copenhagen: National Museum.

——(1955) 'Mit Braggender Flamme'. *Kuml* 1955: 63–130.

Stehrenberger, T. (1997) 'Ein Wurfholz aus der neolitischen Siedlung Arbon'. *Archäologie Schweiz* 20 (2): 54–6.

Stevenson, A. (1998) 'Wet-site contributions to developmental models of Fraser River fishing technology'. In K. Bernick (ed.), *Hidden dimensions: The cultural significance of wetland archaeology*. Vancouver: University of British Columbia Press, 220–38.

Steward, J. H. (1955) *The theory of cultural change.* Urbana: University of Illinois Press.

——(1973) *The theory of culture change: The methodology of multilinear evolution.* Urbana: University of Illinois Press.

Stewart, H. (1984) *Cedar.* Seattle: University of Washington Press.

Stewart, K. M. (1989) *Fishing sites of North and East Africa in the Late Pleistocene and Holocene: Environmental change and human adaptation.* BAR International Series 521. Oxford: Archaeopress.

Stihler, S. D., Stone, D. B., and Beget, J. E. (1992) '"Varve" counting vs. tephrochronology and ^{137}Cs and ^{210}Pb dating: A comparative test at Skilak Lake, Alaska'. *Geology* 20: 1019–22.

Stocker, D., and Everson, P. (2003) 'The straight and narrow way: Fenland causeways and the conversion of the landscape in the Witham Valley, Lincolnshire'. In M. Carver (ed.), *The Cross goes North: Processes of conversion in Northern Europe AD 300–1300*. York: Woodbridge Medieval Press, 271–88.

Stöckli, W. E. (1990*a*) 'Das Verhältnis zwischen Haus- und Wildtierknochen in den neolithischen Ufersiedlungen von Twann (Kt. Bern)'. In J. Schibler, J. Sedlmeier, and H. P. Spycher (eds.), *Festschrift für Hans R. Stampfli*, Basel: Helbing & Lichtenhahn, 273–6.

——(1990*b*) 'Die neolithischen Ufersiedlungen von Twann im Kanton Bern'. In Schweizerisches Landesmuseum (ed.), *Die ersten Bauern*. Zurich: Schweizerisches Landesmuseum, 307–10.

——Niffeler, U., and Gross-Klee, E. (eds.) (1995) *Die Schweiz vom Paläolithikum bis zum frühen Mittelalter SPM II: Neolithikum*. Basel: Schweizerische Gesellschaft für Ur- und Frühgeschichte.

Stone, T., Dickel, D. N., and Doran, G. H. (1990) 'The preservation and conservation of waterlogged bone from the Windover site, Florida: A comparison of methods'. *Journal of Field Archaeology* 17: 177–86.

Stout, M. (1997) *The Irish ringfort*. Dublin: Four Courts.

Strahl, E. (2004) 'Archäologie der Küste: Marsch, Watt, Ostfriesische Inseln'. In M. Fansa, F. Both, and H. Haßmann (eds.), *Begleitschrift zur Ausstellung Archäologie|Land|Niedersachsen. 25 Jahre Denkmalschutzgesetz—400.000 Jahre Geschichte*. Stuttgart: Theiss, 495–510.

Strathern, M. (1988) *Gender of the Gift*. Berkeley: University of California Press.

Streefkerk, J. G., and Casparie, W. A. (1989) *The hydrology of bog ecosystems: Guidelines for management*. Utrecht: Staatsbosbeheer, National Forest Service in the Netherlands.

Strobel, P. (1874) 'Intorno all'origine delle terramare'. *Archivio per l'Antropologia e l'Etnologia* IV: 1–19.

Strömberg, M. (1961) 'Die bronzezeitlichen Schiffssetzungen im Norden'. *Meddenlanden från Lunds Universitets Historiska Museum* 1961: 82–106.

Sukachev, V. N., and Poplavskaya, G. I. (1946) 'Outline of the history of lakes and vegetation of the Middle Urals during the Holocene according to the data of an investigation of sapropel sediments'. *Bulletin de la Commission pour l'Étude du Quaternaire* 8: 5–37.

Sulgostowska, Z. (1998) 'Continuity, change and transition: The case of North-Eastern Poland during the Stone Age'. In M. Zvelebil, L. Domańska, and R. Dennell (eds.), *Harvesting the sea, farming the forest: The emergence of Neolithic societies in the Baltic Region*. Sheffield: Sheffield Academic Press, 87–94.

Suter, P. J., and Schibler, J. (1996) 'Ernährung während der Jungsteinzeit am Bielersee: Modelle und Hypothesen'. In H.-J. Beier (ed.), *Studien zum Siedlungswesen im Jungneolithikum*. Archäologische Fachliteratur. Weissbach: Beier & Beran, 23–42.

——Schlichtherle, H. (2009) *Pfahlbauten—Palafittes—Palafitte*. Berne: Gassmann.

——Hafner, A., and Glauser, K. (2005) 'Prähistorishe und frügeschichtliche Funde aus dem Eis—der wiederentdeckte Pass über das Schnidejoch'. *Archäologie Schweiz* 28: 16–23.

Sutton, D. G., Furey, L., and Marshall, Y. M. (2003) *The archaeology of Pouerua.* Auckland: Auckland University Press.

Swadling, P., and Hide, R. (2005) 'Changing landscape and social interaction: Looking at agricultural history from a Sepik-Ramu perspective'. In A. Pawley, R. Attenborough, J. Golson, and R. Hide (eds.), *Papuan pasts: Cultural, linguistic and biological histories of Papuan-speaking peoples*. Canberra: Australian National University, 289–327.

Szmyt, M. (1996) 'Globular Amphora Culture in Eastern Europe. Present state of research and possibilities for future studies'. *Baltic-Pontic Studies* 4: 3–27.

Taavitsainen, J.-P. (2001) 'Finland'. In B. J. Coles and A. Olivier (eds.), *The heritage management of wetlands in Europe*. Exeter: Europae Archaeologiae Consilium and WARP, 71–80.

Takehiro, F. (2008) 'Coastal wetland sites and coastal cave sites: archaeological and environmental investigations around Lake Nakaumi and Lake Shinji areas, West Japan'. *Journal of Wetland Archaeology* 8: 1–23.

Tarrús, J. (2008) 'La Draga (Banyoles, Catalonia), an Early Neolithic Lakeside Village in Mediterranean Europe'. *Catalan Historical Review* 1: 17–33.

Tezuka, K. (1998) 'North Pacific and Bering Sea Maritime Societies: The archaeology of prehistoric and early historic coastal people'. *Arctic Anthropology* 35 (1): 350–60.

Thayer Morton, A. G. (2004) *Archaeological site formation: Understanding lake margin contexts.* Oxford: Archaeopress.

Therkorn, L., Brandt, R. W., Pals, J. P., and Taylor, M. (1984) 'An early Iron Age farmstead: Site Q of the Assendelver Polders Project'. *Proceedings of the Prehistoric Society* 50: 351–73.

Thesiger, W. (1958) 'Marsh dwellers of southern Iraq'. *National Geographic Magazine* 113 (2): 204–39.

——(1964) *The Marsh Arabs.* London: Longmans, Green & Co.

Thieme, H. (1997) 'Lower Palaeolithic hunting spears from Germany'. *Nature* 385: 807–10.

——(1999) 'Lower Palaeolithic throwing spears and other wooden implements from Schöningen'. In H. Ullrich (ed.), *Hominid evolution: Lifestyles and strategies.* Gelsenkirchen/Schwelm: Edition Archaea, 383–95.

Thomas, F. (1925) *The environmental basis of society.* New York: Century.

Thomas, J. (2004) *Archaeology and modernity.* London: Routledge.

Tiljander, M., Saarnisto, M., Ojala, A. K., and Saarinen, T. (2003) 'A 3000-year palaeoenvironmental record from annually laminated sediment of Lake Korttajarvi, central Finland'. *Boreas* 32: 566–77.

Tilley, C. (1991) 'Review of B. and J. M. Coles [1989] People of the Wetlands [Thames and Hudson]'. *Proceedings of the Prehistoric Society* 56: 214–15.

——(1994) *A phenomenology of landscape: Places, paths and monuments.* London: Berg.

——(2004) *The materiality of stone: Explorations in landscape phenomenology.* Oxford: Berg.

Timofeev, V. I. (1998) 'The beginning of the Neolithic in the Eastern Baltic'. In M. Zvelebil, L. Domańska, and R. Dennell (eds.), *Harvesting the sea, farming the*

forest: The emergence of Neolithic societies in the Baltic Region. Sheffield: Sheffield Academic Press, 225–36.

Timofeev, V. I., Dolukhanov, P. M., Nosov, E. N., Arslanov, K. A., Subetto, D. A., and Zaitseva, G. I. (2005) 'Evolution of the waterways and early human migrations in the North-Eastern Baltic Area'. *Geochronometria* 24: 81–5.

Tinner, W., Lotter, A. F., Ammann, B., Conedera, M., Hubschmid, P., van Leeuwen, J. F. N., and Wehrli, M. (2003) 'Climatic change and contemporaneous land-use phases north and south of the Alps 2300 bc to 800 ad'. *Quaternary Science Reviews* 22: 1447–60.

Tolan-Smith, C. (1998) 'Radiocarbon chronology and the late glacial and early post-glacial resettlement of the British Isles'. *Quaternary International* 49/50: 21–7.

——(2003) 'The social context of landscape learning and the late glacial-early post-glacial recolonization of the British Isles'. In M. Rockman and J. Steele (eds.), *Colonization of unfamiliar landscapes: The archaeology of adaptation*. London: Routledge, 116–29.

Tolar, T., Jacomet, S., Veluscek, A., and Cufar, K. (2010) 'Recovery techniques of waterlogged archaeological sediments—a comparison of different treatment methods of samples from Neolithic Lake shore settlements'. *Vegetation History and Archaeobotany* 19: 53–67.

Torke, W. (1993) 'Die Fischerei am prähistorischen Federsee'. *Archäologisches Korrespondenzblatt* 23: 49–66.

Touchais, G., and Fouache, E. (2007) 'La dynamique des occupation de bord de lacs dans le Sud-Ouest des Balkans: L'Example de Sovjan, bassin de Korçë (Albanie)'. In Congrès national des societé historiques et scientifiques (ed.), *Le Temps*. Besançon: Actes du Congrès, 375–84.

——Lera, P., and Oberweiler, C. (2005) 'L'Habitat protohistorique lacustre de Sovjan (Albanie): Dix ans de recherches franco-albanaises (1993–2003)'. In P. Della Casa and M. Trachsel (eds.), *WES'04: Wetland economies and societies*. Zurich: Chronos, 255–8.

Trigger, B. (1989) *A history of archaeological thought*. Cambridge: Cambridge University Press.

Tringham, R. (1991) 'Households with faces: The challenge of gender in architectural remains'. In J. Gero and M. Conkey (eds.), *Engendering archaeology: Women and prehistory*. Oxford: Blackwell, 93-131.

——(1995) 'Archaeological houses, households, housework and the home'. In D. N. Benjamin, D. Stea, and D. Saile (eds.), *The home: Words, interpretations, meanings and environments*. Aldershot: Avebury, 79–107.

Tripp, J., Higham, T. F. G., and Hedges, R. E. M. (2004) 'A pre-treatment procedure for the AMS radiocarbon dating of sub-fossil insect remains'. *Radiocarbon* 46 (1): 147–54.

Troels-Smith, J. (1990) 'Experiments in forest clearance and slash-and-burn agriculture in Draved Forest in the 1950s'. In D. E. Robinson (ed.), *Experimentation and reconstruction in environmental archaeology*. Oxford: Oxbow, 75–6.

Tuohy, T. (2004) 'Weaving as a domestic craft at the Iron Age site of Glastonbury Lake village in Somerset, Britain'. *Journal of Wetland Archaeology* 4: 97–109.

Turgay, M., and Schlumbaum, A. (2004) 'Untersuchung von alter DNA in Koprolithen von Wiederkäuern'. In S. Jacomet, U. Leuzinger, and J. Schibler (eds.), *Die jungsteinzeitliche Seeufersiedlung Arbon-Bleiche 3*. Frauenfeld: Veröffentlichung des Amtes für Archäologie des Kantons Thurgau, 362–4.

Turner-Walker, G., and Peacock, E. E. (2008) 'Preliminary results of bone diagenesis in Scandinavian bogs'. *Palaeogeography, Palaeoclimatology, Palaeoecology* 266: 151–9.

Turner, R. C. (1995) 'Recent Research into British Bog Bodies'. In R. C. Turner and R. G. Scaife (eds.), *Bog bodies. New discoveries and new perspectives*. London: British Museum Press, 108–22.

——and Scaife, R. G. (eds.) (1995) *Bog bodies: New discoveries and new perspectives.* London: British Museum Press.

Urtans, J. and Rains, V. (2006) 'New discoveries in Latvian Lake dwellings'. In A. Hafner, U. Niffeler, and U. Ruoff (eds.), *Die neue Sicht—Unterwasserarchäologie und Geschichtsbild*: Basel: Archäologie Schweiz, 97–100.

Valdés, J. A. (1998) Kaminaljuyu, Guatemala: descubrimientos recientes sobre poder y manejo hidráulico. *Memorias del Tercer Congreso Internacional de Mayistas, 1995.* Mexico: Centro de Estudias Mayas, 752–70.

Valk, H. (2008) 'Eesti muinaslinnuste kataloog: saatesõna'. In A. Mäesalu and H. Valk (eds.), *Eesti muinaslinnad.* Tallinn: Muinasaja teadus, 179–84.

Vanden Berghe, I., Gleba, M., and Mannering, U. (2009) 'Towards the identification of dyestuffs in Early Iron Age Scandinavian peat bog textiles'. *Journal of Archaeological Science* 36 (9): 1910–21.

——(2010) 'Dyes: to be or not to be? Investigations of dyeing in Early Iron Age Danish bog textiles'. In B. Andersson Strand, M. Gleba, U. Mannering, C. Munkholt and M. Ringgaard (eds.) *North European Symposium for Archaeological Textiles X*: 247–51. Oxford: Oxbow.

Van de Noort, R. (1998) 'The Humber Wetlands Survey: An integrated approach to wetland research and management'. In K. Bernick (ed.), *Hidden dimensions: The cultural significance of wetland archaeology*. Vancouver: University of British Columbia Press, 290–301.

——(2001) 'Recontructing past wetland landscapes—two case studies from the Humber wetlands'. In S. Rippon (ed.), *Estuarine archaeology: The Severn and beyond*. Exeter: The Severn Estuary Levels Research Committee, 163–74.

——(2004*a*) *The Humber Wetlands: The archaeology of a dynamic landscape.* Bollington: Windgather.

——(2004*b*) 'The Humber, its sewn-plank boats, their contexts and the significance of it all'. In P. Clark (ed.), *The Dover Bronze Age boat in context: Society and water transport in prehistoric Europe*: Oxford: Oxbow, 90–8.

——(2011) *North Sea archaeologies. A maritime biography, 10,000 bc–ad 1500.* Oxford: Oxford University Press.

——and Davies, P. (1993) *Wetland heritage: An archaeological assessment of the Humber Wetlands, HumberWetlands Project.* Hull: University of Hull.

——and Ellis, S. (eds.) (2000) *Wetland heritage of the HullValley: An archaeological survey.* Hull: Humber Wetlands Project.

——and O'Sullivan, A. (2006) *Rethinking wetland archaeology.* London: Duckworth.

Van de Noort, R., and O'Sutlivan, A. (2007) 'Places, perceptions, boundaries and tasks: Rethinking landscapes in wetland archaeology'. In J. W. Barber, C. Clark, M. Cressey, A. Crone, A. Hale, J. C. Henderson, R. A. Housley, R. Sands, and A. Sheridan (eds.), *Archaeology from the wetlands: Recent perspectives*. Edinburgh: Society of Antiquaries of Scotland, 79–89.

——Chapman, H. P., and Cheetham, J. (2001) 'Science-based conservation and management in wetland archaeology: The example of Sutton Common, UK'. In B. A. Purdy (ed.), *Enduring records: The environmental and cultural heritage of wetlands*. Oxford: Oxbow, 277–86.

————and Collis, J. R. (2007) *Sutton Common: The Excavation of an Iron Age Marsh Fort*. Research Report 154. York: Council for British Archaeology.

——Middleton, R., Foxon, A., and Bayliss, A. (1999) 'The "Kilnsea-boat", and some implications from the discovery of England's oldest plank boat'. *Antiquity* 73: 131–5.

van der Plicht, J., Beck, J. W., Bard, E., Baillie, M. G. L., Blackwell, P. G., Buck, C. E., Friedrich, M., Guilderson, T. P., Hughen, K. A., Kromer, B., McCormac, F. G., Bronk Ramsey, C., Reimer, P. J., Reimer, R. W., Remmele, S., Richards, D. A., Southon, J. R., Stuiver, M., and Weyhenmeyer, C. E. (2004) 'NotCal04—comparison/calibration C-14 records 26–50 cal kyr BP'. *Radiocarbon* 46 (3): 1225–38.

van der Sanden, W. (1996) *Through nature to eternity: The bog bodies of Northwest Europe*. Amsterdam: Batavia Lion International.

——(1999) 'Wetland archaeology in the province of Drenthe, the Netherlands'. In B. J. Coles, J. M. Coles, and M. S. Jørgensen (eds.), *Bog bodies, sacred sites and wetland archaeology*. Exeter: Wetland Archaeology Research Project, 217–25.

——and Turner, R. (2004) 'The Strata Florida Manikin: How exotic is it?' *Journal of Wetland Archaeology* 4: 83–96.

van der Veen, M. (2007) 'Formation processes of desiccated and carbonized plant remains—the identification of routine practice'. *Journal of Archaeological Science* 34: 968–90.

van Dockum, S., Hallewas, D., van Heeringen, R., and Jungerius, E. (2001) 'The Netherlands'. In B. J. Coles and A. Olivier (eds.), *The heritage management of wetlands in Europe*. Exeter: Europae Archaeologiae Consilium and WARP, 35–45.

Vandorpe, P., and Jacomet, S. (2007) 'Comparing different pre-treatment methods for strongly compacted organic sediments prior to wet-sieving: A case study on Roman waterlogged deposits'. *Environmental Archaeology* 12: 207–14.

van Geel, B., Buurman, J., and Waterbolk, H. T. (1996) 'Archaeological and palaeoecological indications of an abrupt climate change in the Netherlands, and evidence for climatological teleconnections around 2650 BP'. *Journal of Quaternary Science* 11: 451–60.

van Gennep, A. (1908) *Les Rites de passage*. Paris: Émile Nourry.

van Heeringen, R., and Theunissen, L. (2006) 'La Nappe phréatique et le patrimoine archéologique en milieu humide aux Pays-Bas'. In D. Ramseyer and M.-J. Roulière-Lambert (eds.), *Archéologie et érosion—2: Zones humides en péril*. Lons-le-Saunier: Centre Jurassien du Patrimoine, 117–25.

————(2007) 'Archaeological monitoring of (palaeo)wetlands in the Netherlands: From best practice to guidelines'. In J. W. Barber, C. Clark, M. Cressey, A. Crone, A. Hale, J. C. Henderson, R. A. Housley, R. Sands, and A. Sheridan (eds.), *Archaeology from the wetlands: Recent perspectives*. Edinburgh: Society of Antiquaries of Scotland, 49–65.

Vannière, B., Colombaroli, D., Chapron, E., Leroux, A., Tinner, W., and Magny, M. (2008) 'Climate versus human-driven fire regimes in Mediterranean landscapes: The Holocene record of Lago dell'Accesa (Tuscany, Italy)'. *Quaternary Science Reviews* 27: 1181–96.

Van-Zeist, W., and Bakker-Heeres, J. A. H. (1985) 'Archaeobotanical studies in the Levant I. Neolithic sites in the Damascus Basin: Aswad, Ghoureife, Ramad'. *Palaeohistoria* 24: 165–256.

Vayda, A. P., and Rappaport, R. (1976) 'Ecology, cultural and noncultural'. In P. Richerson and J. McEvoy (eds.), *Human Ecology*. 7–28. North Scituate, Mass.: Duxbury.

Velušček, A. (2004) 'Past and present lake-dwelling studies in Slovenia: Ljubljansko barje (the Ljubljana Marsh)'. In F. Menotti (ed.), *Living on the lake in prehistoric Europe: 150 years of lake-dwelling research*. London: Routledge, 69–82.

——(2009) 'Stare gmajne pile-dwelling settlement and its era'. In A. Velušček (ed.), *Stare gmajne pile-dwelling settlement and its era*. Ljubljana: Založba ZRC, 11–34.

Verhoeven, J. T. A. (2009) 'Wetland biogeochemical cycles and their interactions'. In E. Maltby and T. Barker (eds.), *The wetlands handbook*. Oxford: Blackwell, 266–81.

Verkhovskaya, N. B., and Kundyshev, A. S. (1993) 'Environment of the Southern Primorye in the Neolithic and Early Iron Age'. *Bulletin of Far Eastern Branch of the Russian Academy of Sciences* 4 (1): 18–26.

Vermeersch, P. M., Paulissen, E., and Huyge, D. (2000) 'Makhadma 4, a Late Palaeolithic fishing site'. In P. M. Vermeersch (ed.), *Palaeolithic Living Sites in Middle and Upper Egypt*. Leuven: Leuven University Press, 227–70.

Veski, S., Heinsalu, A., Klassen, V., Kriiska, A., Lõugas, L., Poska, A., and Saluäär, U. (2005) 'Early Holocene coastal settlements and palaeoenvironment on the shore of the Baltic Sea at Parnu, southwestern Estonia'. *Quaternary International* 130 (1): 75–85.

Veth, P. (1989) 'Islands in the interior: A model for the colonization of Australia's arid zone'. *Archaeology in Oceania* 24 (3): 81–92.

——Smith, M. A., and Hiscock, P. (eds.) (2005) *Desert peoples: Archaeological perspectives*. Oxford: Blackwell.

Virtanen, K. (2006) *Esialgne aruanne Koorküla Valgjärve allveearheoloogilisest uurimisest*. Helsinki: National Heritage Board.

Vogt, A. M. (2004) 'Le Corbusier im Bann des "Pfahlbau-Fiebers"'. In Antiquarische Gesellschaft in Zürich (ed.), *Pfahlbaufieber: Von Antiquaren, Pfahlbaufischern, Altertümerhändlern und Pfahlbaumythen*. Zurich: Chronos, 203–11.

Vogt, E. (1951) 'Das steinzeitliche Uferdorf Egolzwil 3 (Kt. Luzern). Bericht über die Ausgrabung 1950'. *Zuschrift für Schweizerische Archäologie und Kunstgeschichte* 12: 193–219.

——(1955) 'Pfahlbaustudien'. In W. U. Guyan, H. Levi, W. Lüdi, J. Speck, H. Tauber, J. Traels-Smith, E. Vogt, and M. Welten (eds.), *Das Pfahlbauproblem*. Basel: Birkhäuser, 119–219.

von Burg, A. (2002) 'Die Glockenbeckerkultur auf dem Plateau von Bevaix'. *Archäologie Schweiz* 25 (2): 48–57.

Vuorela, I. (1998) 'The transition to farming in Southern Finland'. In M. Zvelebil, L. Domańska, and R. Dennell (eds.) *Harvesting the sea, farming the forest: The*

emergence of Neolithic societies in the Baltic Region: 175-80. Sheffield: Sheffield Academic Press

Waddington, C. (2007) 'Rethinking Mesolithic settlement and a case study from Howick'. In C. Waddington and K. Pedersen (eds.), *Mesolithic studies in the North Sea Basin and beyond: Proceedings of a conference held at Newcastle in 2003*. Oxford: Oxbow, 101–13.

——Bailey, G., Bayliss, A., Boomer, I., Milner, N., Pedersen, K., Shiel, R. and Stevenson, T. (2003) 'A Mesolithic settlement site at Howick, Northumberland: A preliminary report'. *Archeologia Aeliana* 32: 1–12.

Wahlbrink, T., Daniel Küpper, G., Y. M., Bolten, J., Möller, M. D. K., Lemme, M. C., and Kurz, H. (2006) 'Supercritical drying process for high aspect-ratio HSQ nano-structures'. *Microelectronic Engineering* 83: 1124–7.

Walker, B., Steffen, W., Canadell, J., and Ingram, J. (1999) *The terrestrial biosphere and global change: Implications for natural and managed ecosystems.* Cambridge: Cambridge University Press.

Walker, J. H. (2008) 'Pre-Columbian ring ditches along the Yacuma and Rapulo Rivers, Beni, Bolivia: A preliminary review'. *Journal of Field Archaeology* 33 (4): 413–27.

Wallace, B. L. (1991) 'L'Anse aux Meadows: Gateway to Vinland'. *Acta Archaeologica* 61: 166–97.

——(2000) 'The Viking settlement at L'Anse aux Meadows'. In W. W. Fitzhugh and E. I. Ward (eds.), *Vikings: The North Atlanctic saga.* Washington: Smithsonian.

Wallace, R. T., and Irwin, G. J. (2004) 'The wooden artefacts from Kohika'. In G. J. Irwin (ed.), *Kohika: The archaeology of a late Maori lake village in the Ngati Awa rohe, Bay of Plenty, New Zealand*. Auckland: Auckland University Press, 83–121.

——Irwin, G. J., and Neich, R. (2004) 'Houses, pataka and woodcarving at Kohika'. In G. J. Irwin (ed.), *Kohika: The archaeology of a late Maori lake village in the Ngati Awa rohe, Bay of Plenty, New Zealand.* Auckland: Auckland University Press, 122–48.

Walters, G. (2001) 'Threats and pressures on wetland environments in England and Wales and the response of the Environment Agency'. In B. J. Coles and A. Olivier (eds.), *The heritage management of wetlands in Europe*. Exeter: Europae Archaeologiae Consilium and WARP, 17–22.

Walton, P. (1988) 'Dyes and wools in Iron Age textiles from Norway and Denmark'. *Journal of Danish Archaeology* 7: 144–58.

Wang, N. Y. (2007) *Long Ago Villages.* Hangzhou: Zhejiang Photo Press.

Warner, R. B. (1983) 'Ireland, Ulster and Scotland in earlier Iron Age'. In A. O'Connor and D. Clark (eds.), *From the Stone Age to the 'forty-five'.* Edinburgh: Edinburgh University Press.

——(1994) 'On crannógs and kings: (part 1)'. *Ulster Journal of Archaeology* 57: 61–9.

Warren, G. (2000) 'Seascapes: People, boats and inhabiting the later Mesolithic in Western Scotland'. In R. Young (ed.), *Mesolithic lifeways: Current research from Britain and Ireland*. Leicester: Leicester University Press, 97–104.

Waterbolk, H. T., and van Zeist, W. (eds.) (1991) *Niederwil, eine Siedlung der Pfyner Kultur,* iv. *Holzartefakte und Textilien.* Berne: Paul Haupt.

Watson, C. (2005) *Seahenge: An archaeological conundrum.* Swindon: English Heritage.

Wazny, T. (2002) 'Baltic timber in Western Europe—an exciting dendrochronological question'. *Dendrochronologia* 20 (3): 313–20.

Weiner, J. (1994) 'Well on my back—an update on the Bandkeramik wooden well of Erkelenz-Kückhoven'. *NewsWARP* 16: 5–17.

Weller, A., Nordsiek, S., and Bauerochse, A. (2006) 'Spectral induced polarisation—a geophysical method for archaeological prospection in peatlands'. *Journal of Wetland Archaeology* 6: 105–25.

Wells, P. S. (1998) 'Identity and material culture in later prehistory of central Europe'. *Journal of Archaeological Research* 6: 239–98.

——(2001) *Beyond Celts, Germans and Scythians: Archaeology and identity in Iron Age Europe*. London: Duckworth.

Wendorf, F., Schild, R., and Close, A. E. (1989) *The prehistory of Wadi Kubbaniya III: Late Palaeolithic archaeology.* Dallas: Southern Methodist University Press.

Wetherall, K., Moss, R. M., Jones, A. M., Smith, A. D., Skinner, T., Pickup, S. W., Goatham, S., Chadwick, A., and Newport, R. (2008) 'Sulphur and iron speciation in recently recovered timbers of the Mary Rose revealed via X-ray absorption spectroscopy'. *Journal of Archaeological Science* 35 (5): 1317–28.

Weymouth, J. W. (1986) 'Geophysical methods of archaeological site surveying'. In M. B. Schiffer (ed.), *Advances in archaeological method and theory.* Orlando: Academic Press, 311–95.

Whitehouse, N. J. (2006) 'The Holocene British and Irish ancient forest beetle fauna: Implications for forest history, biodiversity and faunal colonisation'. *Quaternary Science Reviews* 25: 1755–89.

Whitmore, T., and Turner II, B. L. (2001) *Cultivated landscapes in Mesoamerica on the eve of the conquest.* Oxford: Oxford University Press.

Whittle, A. (2010) 'The diversity and duration of memory'. In D. Borić (ed.), *Archaeology and memory.* Oxford: Oxbow.

Wilde, W. R. (1840) 'Antiquities recently discovered at Dunshaughlin'. *Proceedings of the Royal Irish Academy* 1: 420–26.

Wilkinson, K., and Stevens, C. (2003) *Environmental archaeology: Approaches, techniques and applications.* Stroud: Tempus.

Wilkinson, T. J. (1997) 'The history of the Lake of Antioch: A preliminary note'. In G. Young, M. Chavalas, and R. Averbeck (eds.), *Crossing boundaries and linking horizons: Studies in honor of Michael C. Astour on His 80th Birthday*. Bethesda: CDL, 557–76.

Willerslev, E., Cappellini, E., Boomsma, W., Nielsen, R., Hebsgaard, M. B., Brand, T. B., Hofreiter, M., Bunce, M., Poinar, H. N., Dahl-Jensen, D., Johnsen, S., Steffensen, J. P., Bennike, O., Schwenninger, J.-L., Nathan, R., Armitage, S., de Hoog, C.-J., Alfimov, V., Christl, M., Beer, J., Muscheler, R., Barker, J., Sharp, M., Penkman, K. E. H., Haile, J., Taberlet, P., Gilbert, M. T. P., Casoli, A., Campani, E., and Collins, M. J. (2007) 'Ancient biomolecules from deep ice cores reveal a forested Southern Greenland'. *Science* 317: 111–14.

Williams, B. B. (1978) 'Excavations at Lough Eskragh, Co. Tyrone'. *Ulster Journal of Archaeology* 41: 37–48.

Williams, E. (1988) *Complex hunter-gatherers. A Late Holocene example from temperate Australia.* BAR International Series 423. Oxford: Archaeopress.

Williams, M. (1990) 'Understanding wetlands'. In M. Williams (ed.), *Wetlands, a threatened landscape*. Oxford: Blackwell, 1–41.

Willigan, J. D., and Lynch, K. (1982) *Sources and methods of historical demography.* New York: Academic Press.

WinklerPrins, A. M. G. A. (2002) 'Seasonal floodplain-upland migration along the Lower Amazon River'. *The Geographical Review* 92 (3): 415–31.

Wood-Martin, W. G. (1886*a*) 'Description of a crannog site in the County Meath'. *Proceedings of the Royal Irish Academy* 16: 480–4.

——(1886*b*) *The lake-dwellings of Ireland: or ancient lacustrine habitations of Erin commonly called crannogs.* Dublin: Hodges Figgis.

Wright, E. V. (1990) *The Ferriby boats: Seacraft of the Bronze Age.* London: Routledge.

——Hedges, R. E. M., Bayliss, A., and Van de Noort, R. (2001) 'New AMS dates for the Ferriby boats; a contribution to the origin of seafaring'. *Antiquity* 75: 726–34.

Wyss, R. (1973) *Wirtschaft und Gesellschaft in der Jungsteinzeit.* Berne: Francke.

——(1976) *Das jungsteinzeitliche Jäger-Bauerndorf von Egolzwil 5 in Wauwilermoos.* Zurich: Schweizerischen Landesmuseum.

——(1990) 'Der Burgäschisee als Siedlungszentrum'. In Schweizerisches Landesmuseum (ed.), *Die ersten Bauern*. Zurich: Schweizerisches Landesmuseum, 293–6.

Zvelebil, M., and Lillie, M. (2000) 'Transition to agriculture in eastern Europe'. In T. D. Price (ed.), *Europe's first farmers*. Cambridge: Cambridge University Press, 57–92.

——and Moore, J. (2006) 'Assessment and representation: The informative value of Mesolithic landscapes'. In E. Rensink and H. Peeters (eds.), *Preserving the Early Past: Investigation, selection and preservation of Palaeolithic and Mesolithic sites and landscapes*. Amersfoort: National Service for Archaeological Heritage, 151–65.

Zwahlen, H. (ed.) (2003) *Die jungneolithische Siedlung Port-Stüdeli.* Berne: Haupt.

Index